U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS

SOIL SURVEY OF OLMSTED COUNTY MINNESOTA

BY

J. AMBROSE ELWELL, IN CHARGE, AND G. B. SHIVERY,
B. H. HENDRICKSON, MARK BALDWIN,
AND A. T. SWEET

[Advance Sheets—Field Operations of the Bureau of Soils, 1923]

UNITED STATES
GOVERNMENT PRINTING OFFICE
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[PUBLIC RESOLUTION—No. 9]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]

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SOIL SURVEY OF OLMSTED COUNTY, MINNESOTA

By J. AMBROSE ELWELL, in Charge, and G. B. SHIVERY, B. H. HENDRICKSON, MARK BALDWIN, and A. T. SWEET

COUNTY SURVEYED

Olmsted County is in the southeastern part of Minnesota. Winona County on the east separates it from Mississippi River, which forms the boundary between Minnesota and Wisconsin; Mower and Fillmore Counties on the south separate it from the State of Iowa; Wabasha and Goodhue Counties border it on the north; and Dodge County borders it on the west. Rochester, the county seat, is about 75 miles southeast of St. Paul and Minneapolis.

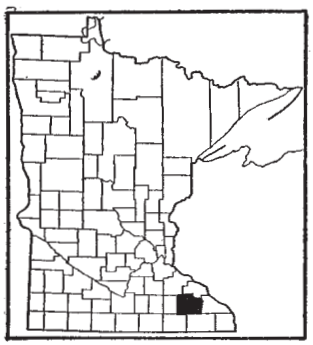

FIG. 33.—Sketch map showing location of Olmsted County, Minn.

Olmsted County is almost rectangular in shape, straight lines indicating its boundaries. It is composed of 18 townships and has a total area of 666 square miles or 426,240 acres. It was established under Territorial government in 1855, but was not organized until 1858.

Topography.—Olmsted County is part of an undulating or rolling plain varying in altitude from 1,200 to 1,250 feet above sea level. (Pl. 41, fig. 1.) The surface is well dissected by drainage valleys, the larger of which are bordered by steep rock bluffs, rising from 50 to 300 feet above the valleys. These bluffs are the most conspicuous topographic features of the county. (Pl. 41, fig. 2.) The most nearly level uplands are in the extreme southwestern corner of the county, and the most rolling uplands are near the lower stream courses. There are small gravel knolls and low gravel ridges throughout the county except in the extreme eastern part, and these make the surface uneven. This condition is most noticeable in Oronoco Township.

Three rivers, South Branch Zumbro, Whitewater, and North Branch Root, furnish drainage outlets for the county. Branches of Zumbro River drain the central, western, and northwestern parts of the county, Middle and South Branches having a good rate of flow which in two places is utilized for water power. A large water-power project in Wabasha County has reduced the rate of flow of these streams within Olmsted County. A sluggish flow occurs only in Cascade Creek watershed and small tributary drainage ways, principally in Rock Dell Township, the narrower and more deeply dissected portion of the valley being in Oronoco Township. In Rochester Township there are several tributaries with wider, less deeply

dissected valleys in the upper courses. In the valley of South Branch Zumbro River in Rochester Township strips of alluvial lands are somewhat more than one-half mile wide, but in the other valleys strips of alluvial land are not so wide.

Population.—According to the 1920 census the population of the county was 28,014, of whom 14,292 were classed as rural. There was an average of 21.5 persons to a square mile. The rural population is mostly American born and is well distributed through the county, but there are communities of Germans in Farmington and in part of Oronoco Townships, Scandinavians in Rock Dell and in Salem Townships, and Irish in Elmira, Orion, and Pleasant Grove Townships.

The county has six incorporated towns, Rochester, the county seat, being the largest, with a population of 13,722, according to the 1920 census. The others are Stewartville, 941; Eyota, 403; Byron, 302; and Dover, 266. Chatfield, on the southern boundary, lies chiefly in Fillmore County. It has a total population of 1,382, only 395 of whom are included in the population of Olmsted County. Other settlements are Oronoco, Douglas, Pleasant Grove, Simpson, and Marion.

Communications.—Railroad facilities consist of four branches of the Chicago & North Western Railway and the Chicago Great Western Railroad systems. Two of these extend north and south and two east and west through the county. These facilities make the markets of St. Paul, Milwaukee, and Chicago easily accessible.

There are four State highways and at the time of this survey the county had 168 miles of well-kept gravel road. There are rural schools throughout the county and consolidated schools are located at Byron, Dover, and Eyota.

Markets.—Besides the towns of the county there are several smaller trading centers which provide local markets for produce. For fattened cattle, corn, and small grains, principally rye, Chicago is the principal outside market. St. Paul also is a market for these products. For fat hogs, Winona and Austin are the principal outside markets, though smaller numbers go to Chicago. Barley is shipped principally to Milwaukee and flax to Minneapolis and Des Moines.

CLIMATE

Olmsted County has warm, short summers and long, cold winters. During the comparatively short frost-free season the weather is bright and sunny, with sufficient rainfall in most years. Crops grow rapidly and mature early in this climate. Early spring and late fall are characterized by warm, sunny days with cool, frosty nights, which are favorable for growing fall-planted grain and for continued growth of pasturage. The grazing season lasts from April to late November. As much plowing as possible is done in the fall in order to lighten spring work and have the land in good condition for early planting. It also allows better moisture absorption by the soil during the winter.

Temperature.—The mean annual temperature at Rochester is 43.2° F. The mean temperatures for December, January, February, and March are below freezing, January being the coldest month with an average temperature of 9.5°. July is the warmest month, showing an average temperature of 71.3°. The lowest temperature recorded was −42° in January; the highest, 104° in July.

The average date of the last killing frost at Rochester is May 9, and of the first, September 28, giving an average frost-free season of 142 days. The latest frost on record occurred on May 24; the earliest on August 30.

Precipitation.—The mean annual precipitation at Rochester is 27.89 inches, distributed throughout the seasons as follows: Winter, 2.37 inches; spring, 7.74 inches; summer, 11.27 inches; and fall, 6.51 inches. Sixty-four per cent of the mean annual precipitation occurs during the frost-free period from May to September, inclusive. During the driest year on record, 1910, only 11.65 inches of precipitation was recorded. The wettest year was 1911, when the total precipitation for the year was 36.73 inches. Usually, however, the rainfall is adequate and so distributed as to insure good yields on most soils. June is normally the wettest month of the year. Midsummer droughts of three or more weeks occur frequently in July. Spring-planted small grain sometimes fails to mature on account of dry weather in midsummer. The yield of corn also is reduced considerably if drought continues through the growing season.

The average annual fall of snow is 40.4 inches. There is usually sufficient snowfall to keep the ground covered during the winter months, thus affording protection to grasses and fall-planted grain. Occasionally open winters occur, with alternate freezing and thawing which causes considerable injury to vegetation.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation at Rochester, which is situated near the center of the county:

Normal monthly, seasonal, and annual temperature and precipitation at Rochester

[Elevation, 991 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1911)	Snow, average depth
	° F.	° F.	° F.	*Inches*	*Inches*	*Inches*	*Inches*
December	17.7	62	−30	0.75	0.45	2.61	6.5
January	9.5	50	−42	.88	1.65	.70	10.1
February	14.4	58	−32	.74	.05	1.65	7.1
Winter	13.9	62	−42	2.37	2.15	4.96	23.7
March	28.6	82	−20	1.28	Trace.	.65	7.5
April	44.4	88	7	2.38	.77	1.86	1.9
May	56.3	93	21	4.08	2.35	4.17	.1
Spring	43.1	93	−20	7.74	3.12	6.68	9.5
June	66.8	99	33	4.88	Trace.	3.38	.0
July	71.3	104	40	3.06	.84	2.15	.0
August	68.3	99	32	3.33	2.94	6.08	.0
Summer	68.8	104	32	11.27	3.78	11.61	.0
September	60.2	100	22	2.57	1.98	2.74	.0
October	47.7	89	−6	2.27	.42	9.11	1.3
November	32.8	77	−24	1.67	.20	1.63	5.9
Fall	46.9	100	−24	6.51	2.60	13.48	7.2
Year	43.2	104	−42	27.89	11.65	36.73	40.4

AGRICULTURE[1]

HISTORY

The first settlement in Olmsted County was made by refugees from the Red River Valley of Canada a few years prior to 1836. In 1840 these settlers moved east of Mississippi River. In 1841 the first farming settlement was established in what is now Rock Dell Township. The principal crops raised at that time were oats, corn, peas, beans, barley, wheat, buckwheat, and rye. The livestock were cattle, horses, hogs, milk cows, and sheep. A prosperous period was followed by the panic of 1857, but the census of 1860 shows advancement in all agricultural lines, notably in wheat production, dairying, and hog raising.

During the early years agriculture was the basic industry of the county. In 1865 the first railroad in the county was constructed, the present east and west branch of the Chicago & North Western Railway. This gave an impetus to settlement of prairie land heretofore considered inaccessible.

By 1870 the county was well settled and by 1880, on account of the increase in railroad facilities, it had reached its present state of settlement. In 1870 the rural population was the largest of any census year. Since that date the rural population has remained practically the same, but the growth of Rochester, the county seat, has increased until the population of that city now nearly equals the rural population. During the period 1860–1870 the change from self-sustaining agriculture to that of the export type took place. The Civil War created an export demand particularly for wool and wheat, which gave a temporary stimulus to sheep raising and a more lasting impetus to wheat growing. In 1870 the crops ranked as follows in order of acreage: Wheat, oats, hay, corn, barley, potatoes, and rye. The greatest development in the livestock industry was in the improvement of dairy cattle.

The census of 1880, at the close of the next 10-year period, shows that the average size of farms was 251 acres. This expansion was brought about by the settlement of new prairie lands. At that time also the percentage of farm owners was 83.1 per cent, which is higher than that for any census year reported since. Agricultural products were produced in greater surplus for export during the period 1870–1880. Improved milling facilities and higher market prices proved an impetus to wheat growing, 152,204 acres being reported for 1879. Other crops grown were the same as those reported by previous censuses. Of these, hay and barley showed the greatest increase in production. Hogs and sheep increased greatly in numbers.

This period saw also the development of diversified farming, and the decline of wheat as a special market crop. The larger farms were divided and rented to tenant operators, and more land was tilled. Barley, rye, and flax production increased greatly; but corn, hay, and oats all show smaller increases. The more extensive use of tame-hay grasses was noticeable and hay became the most important crop. At

[1] Historical data preceding and supplementing the Federal census were obtained from Robinson's Early Economic Conditions in Minnesota, 1915.

this time commercial apple growing became a new industry. Hog and cattle raising and dairying showed the largest growth among livestock industries. Creameries and cheese factories were started in connection with the dairying business.

The period 1880–1890 was marked by continued diversification and greater production of crops for export. The greatest acreage increases were in barley, flax, wheat, and potatoes. Decreased acreages in rye and hay (mostly wild hay) were reported. Although the crops grown were the same as reported in former censuses, barley held first place in acreage seeded. The census enumerations of livestock show a slight decrease in the number of dairy cattle, and increases in all other livestock, chiefly in the number of sheep.

The percentage of land in farms reached a maximum of 95.1 per cent in 1900. In that year the census reported the largest total acreage of the following crops for any census year: Barley, 70,932 acres; oats, 59,063; corn, 38,128; tame hay, 29,806; wheat, 24,487; and flax, 14,922 acres. Decreases in acreage planted to barley, corn, and wild hay occurred.

In 1910 crops according to their acreage were as follows: Barley, oats, corn, tame hay, wheat, coarse forage, wild hay, flax, and potatoes. The livestock census showed an increase in dairy cattle, hogs, horses, and poultry, the numbers exceeding those of any other census year, but decreases in sheep and beef cattle.

Dairying received increased attention in 1920, when 12 creameries, 3 ice-cream factories, and 10 cheese factories were operating within the county. Oats became the leading grain crop, and corn second in importance.

Little change is noted by comparison of the 1920 Federal census and the last [2] State census of the Minnesota agricultural department for 1923. A slight decrease in tenancy and increase in size of farms is shown. The greatest crop acreage increase was that of flax, the acreage being tripled in the three-year period. Tame hay increased one-fourth in acreage, rye nearly doubled, oats increased one-fifth, and corn one-tenth.

The acreage of clover and timothy hay, rye, oats, and corn in 1923 were greater than any reported by the Federal census. The acreage in wheat, barley, and potatoes decreased. The 1923 State livestock census showed slight decreases in the number of cattle, horses, and sheep, and an increase in the number of hogs. General farming, well diversified and combined with grain and livestock production, is practiced in the county.

CROPS AND MARKETS

The crops grown are corn, oats, timothy and clover hay, barley, flax, rye, timothy seed, wheat, wild hay, clover seed, potatoes, buckwheat, and alfalfa. Oats, barley, rye, flax, corn, wheat, and buckwheat are the principal market crops.

Corn is the largest crop in acreage and production. The 1920 census reports a total of 65,578 acres, in 1919, of which 37,834 acres

[2] Statistics quoted for the crop year 1923 were obtained from records furnished by the census of the Minnesota State department of agriculture.

were for grain, 19,811 acres for fodder, and 7,933 acres for silage. Corn is used as feed on the farms, the annual marketing of this crop probably not exceeding 20 or 25 per cent of the grain produced. From 30 to 35 bushels an acre is the usual yield. Yellow dent varieties are most commonly used, with white dent varieties being less common. Mixed home-grown seed usually is used. Yellow Murdock and Minnesota 13 are the most popular yellow dent varieties, and Silver King is the most common white dent. The marketing of corn is through local elevators, and it is consigned chiefly to the Chicago grain market.

The oat crop is second in importance. The 1920 census reported 49,010 acres for 1919, and the Minnesota State census for 1923 reported 61,237 acres. From two-thirds to three-fourths of the oats produced is used as feed on the farms and the rest is marketed. Yields vary from 30 to 40 bushels an acre. Home-grown seed, principally strains of the Kherson, Green Russian, and Silvermine varieties, is used. The early maturing varieties are more popular than the late maturing. The marketing of oats is cared for by local elevators, and it is consigned mainly to the Chicago market.

In acreage wheat ranks third among the grain crops and barley fourth, but in production the standing is reversed, the barley output doubling that of wheat. The 1920 census reports for 1919 an acreage in barley of 24,261, and the 1923 Minnesota State census reports 20,871 acres. More than half the grain produced is marketed through local elevators, Milwaukee being the principal outside market, and the remainder is used as feed on the farms. The average yield varies from 25 to 30 bushels an acre. The seed used is mainly a mixed home-grown selection.

According to the 1923 Minnesota State census flax ranks next in acreage among the grain crops, there being 9,589 acres. The 1920 census reported only 3,693 acres in 1919, which shows an increase in recent years. The seed generally used is of the wilt-resistant strains. From 10 to 15 bushels an acre is the average yield. Flaxseed is marketed through local elevators and consigned chiefly to Minneapolis and Des Moines, and there is a small market for the straw.

There were 4,826 acres of rye in 1919 and 7,427 acres in 1923. Winter rye only is seeded and yields average from 15 to 20 bushels an acre. Perhaps three-fourths or more of the grain is marketed. This is sold to local elevators principally for the Chicago market.

At the present time wheat is the least important of the grain crops, there being only 3,349 acres in 1923. Yields averaged from 15 to 20 bushels an acre. About two-thirds of the wheat sown is spring wheat and the remainder is winter wheat. The Marquis variety of spring wheat is the most popular. A mill in Rochester receives most of the grain marketed. Outside shipments are in very small quantities. Approximately one-half of the production is used as feed on the farms, except in exceptionally good market years. So-called "succotash mixtures" of oats and barley, oats and wheat, or wheat and barley are grown.

In 1919 there were 69,877 acres in hay and forage crops. There were 42,112 acres in hay crops, 19,832 acres in forage crops, and

7,933 acres in silage crops. Tame-hay grasses are the principal hay crop, there being 39,832 acres in 1919. There were 2,096 acres of wild hay, yielding an average of 1½ tons an acre. The tame-hay grasses rank in acreage as follows: Timothy and clover mixed, 27,640 acres; timothy, 10,768 acres; clover, 1,132 acres; and millet, alfalfa, sweet clover, alsike clover, and miscellaneous grasses are also grown. Their average yields are as follows: Alfalfa, 2½ tons an acre; clover, 2 tons; timothy and clover mixed, 1¾ tons; and timothy, between 1½ and 1¾ tons. The second cutting of clover and about one-half of the timothy usually are harvested for seed. Seasonal conditions greatly influence the production of clover seed and to some degree timothy seed. Medium red clover is the predominant clover seeded, but some Mammoth red, alsike clover, and sweet clover also are grown.

Alfalfa has not given satisfactory returns in Olmsted County because of poor seed, unfavorable soil conditions, or indifferent care in seeding and maintenance of stands. On account of its high yields and its benefit as a soil improver, efforts are constantly being made to increase its use. Millet and Sudan grass, short-season hay crops, are also grown. Nearly all the hay is used locally, and in short-crop seasons considerable quantities are shipped in.

Of the 1919 forage crops, of which there were 19,832 acres, fodder corn was the largest. Sorghum, soy beans, and rape are minor forage crops. Soy beans and rape crops are sown alone or in combination seedings with corn and small grains. Fodder corn yields 6 or 8 tons an acre.

Corn is the principal silage crop. Yields average 8 or 10 tons an acre. Soy beans and sorghum are minor silage crops used both in separate seedings and in combination seeding with corn. Sorghum is used for production of sirup for home consumption.

According to the 1923 Minnesota State census there were 68,257 acres in permanent pasture, and 39,949 acres of previously plowed land were also in pasture. Bluegrass is the most common pasture grass, and timothy, alsike or white clover, and ryegrass are sometimes used in reseeding mixtures. Plowed land is converted to pasture by establishing clover and timothy hay meadows. Clover usually is reseeded every third year and timothy about every fourth year.

Crops of minor importance are buckwheat, Canadian field peas, potatoes, emmer, and spelt. Buckwheat is entirely a cash crop. Canadian field peas are sown alone or with oats and barley. Emmer and spelt are sometimes grown in the rotation in place of other small grains. Potatoes are grown mainly for home consumption and the surplus is marketed.

Small fruits are grown for farm consumption and for local marketing. In 1919, 56 acres of strawberries and 29 acres of raspberries were reported. Orcharding is engaged in as a side line, receiving general but indifferent attention. Apples are the principal orchard product. Wealthy and Oldenburg (*Duchess of Oldenburg*) varieties are most common. Plums and cherries are the only other tree fruits reported by the 1920 census. Grapes also are raised. The small surplus of orchard produce is marketed locally.

LIVESTOCK AND ANIMAL PRODUCTS

Hogs, dairy cattle, beef cattle, horses, and sheep are raised. The raising and fattening of hogs is engaged in more extensively than any other livestock industry. In the Minnesota State census of May 1, 1923, a total of 62,012 hogs was reported. The January 1, 1920, Federal census reports a total of 57,085 hogs. The largest hog breeders of the county keep about 40 brood sows. Considerable attention is given to the maintenance of breed standards, but only 75 farms specialize in purebreds. The breeds rank in popularity approximately as follows: Duroc-Jersey, Poland-China, Chester White, and Hampshire. The stock is in good, sturdy condition and losses from cholera and other disorders are rare. Winona and Austin, Minn., and Chicago, Ill., are the principal outside markets. Cooperative shipping associations throughout the county take care of most of the market production.

Dairy cattle rank second to hogs in numbers, totaling 32,637. According to the 1920 report of the Minnesota State dairy commissioner the 12 creameries and 10 cheese factories in the county reported a total of 1,935 patrons milking 16,787 cows, and an output of 2,129,536 pounds of butter and 1,120,715 pounds of American cheese. Three ice-cream factories used the additional dairy produce of the county. According to the Federal census, the total value of dairy products in 1919 was $1,510,307. The breeds of dairy cattle rank in popularity as follows: Holstein, Guernsey, Brown Swiss, Jersey, and Ayrshire. Some dual-purpose stock of Shorthorn and Red Poll breeds also are kept. However, most of the dairy animals are of grade stock.

The raising and fattening of cattle for market ranks third as a livestock enterprise. The 1920 census reported 28,843 beef cattle in the county. The animals are raised on pasturage and roughage and finished on concentrated feeds and roughage. Very few cattle are shipped into the county for fattening. Beef cattle are sold through cooperative shipping associations at various shipping points in the county and are consigned to Chicago and St. Paul markets. Beef cattle usually are of Shorthorn, Hereford, Angus, and Red Poll breeds.

There were 14,341 horses, 98 mules, and 6 asses and burros in the county. The horses are of draft-horse stock and supply the home demand, with a small surplus for local markets. Considerable attention is given to improvement in breeds of stock, Percheron being the most popular.

Sheep raising is also practiced. According to the personal property assessment figures of 1923, there were 10,911 sheep in the county; 3,951 of this number were shorn, producing about 25,000 pounds of wool. Sheep for market are consigned to Chicago and St. Paul. They are practically all of native stock, as very few farmers specialize in purebreds. Shropshire is the most popular breed.

Poultry raising is of importance on nearly every farm. According to the 1920 census, there were 211,642 chickens and 5,946 other poultry, such as ducks, geese, and turkeys. Local poultry and produce agencies take care of the marketing of these products. There were reported 1,458 hives of bees which produced 31,549 pounds of honey.

COMMON FARM PRACTICES

The soils of Olmsted County are well adapted to general farming. Corn produces better on silt loam soils than on sandier-textured soils, and darker-colored, deeper, silt loam soils are considered more adapted to corn than lighter-colored, shallower soils. The sandy soils are better adapted to rye and buckwheat than to other grain crops, but these are grown also on silt loams. Flax does not produce so well on old ground as upon recently plowed grassland. Cultivated hay crops suffer on lighter soils in times of low rainfall and as a rule produce better on silt loam soils. Rough stony land and soils with a rolling surface are kept in pasture or forest.

The cropping practices of the county center about the growing of corn, small grains, and tame hay. The common practice is to plant corn and small grains for from 2 to 5 years and then tame hay and pasture for the same length of time. Systematic crop rotation is a steadily increasing practice, however. A 4-year rotation usually followed is corn, small grain, clover and timothy 2 years, and back to corn. Variations are small grains 2 years, corn 2 years, or clover and timothy pasture the third and fourth year.

When possible, land for corn is plowed in the fall and is disked and harrowed in the spring. Corn is generally planted between May 8 and May 20, unless it is to be used for silage or fodder, when it may be planted somewhat later. The later planting is generally made on a seed bed prepared from sod land as a safeguard against damage from cutworms and wireworms. Checkrow planting is most common when corn is grown for grain but for silage and fodder the seed is often drilled. From three to five cultivations generally are possible before hay or small-grain harvest demand attention. The most troublesome weeds are Canadian thistle and quack grass. Foxtail, ragweed, ironweed, buttonweed, cocklebur, bull thistle, yellow dock, and wild lettuce are other weeds which cause some trouble.

Corn for grain usually matures late in September or early in October. Selection of the earlier-maturing ears for seed is sometimes practiced. Silage or fodder corn is cut from September 1 to 10. Occasionally soy beans are planted in combination with corn for silage or to be "hogged down." Stubble land is utilized for winter pasturage. For a second corn crop, the ground is plowed in the spring. For small grains, corn-stubble land is generally disked and harrowed, the seeding being done between April 1 and 15.

Small grain is usually harvested between July 15 and August 1. Small grains generally are used as a nurse crop for clover and timothy. Where a poor stand is obtained or no hay grass is seeded, the small-grain stubble is plowed in the fall for either corn or small grains. Sometimes rye is sown, between September 15 to October 1, on disked stubble. Winter-rye harvest precedes the harvest of oats, wheat, and barley. When the grass obtains a stand after small-grain harvest, no hay is cut nor is the pasture used that fall except in an unusually good growing season. The following year two cuttings of clover and timothy hay usually are obtained. The second crop of clover is sometimes harvested for seed. Seed from timothy ordinarily is not harvested until the second year's growth. In case of a poor stand of hay it is often necessary to reseed. If corn is to be

planted the following year the land is usually plowed in the fall. Timothy and clover sod is often retained as the foundation of additional pasture land, in which case clover is usually reseeded every third year and timothy every fourth year.

The acreage of alfalfa has been very small until recently. In 1923 there were only 202 acres in the county. Since that time it has increased greatly from year to year. It is sown either in the spring with a nurse crop or in the summer without. Inoculation is practiced, and liming has been found desirable in most cases.

New ground is recognized as best suited to flax, but in years of good markets the crop is more widely sown. It is seeded between May 1 and May 10 and is harvested between August 15 and September 1. Usually it is seeded for only one year and never for more than two years on the same ground.

Manure produced on the farm is the only fertilizer ordinarily used. It is applied most commonly upon hay meadows or small-grain stubble preparatory to planting corn, or as a top-dressing for pastures, young hay growth, or meadows. Lime is used to a small extent on ground prepared for alfalfa and clover seeding. Commercial fertilizers are used only to a small extent for special crops, mostly truck crops. According to the 1920 census, only 68 of the 2,287 farms reported an expenditure for fertilizers, averaging $251.60 a farm. Green manuring is seldom practiced. Occasionally the second crop of red clover or sweet clover is plowed under.

FARM EQUIPMENT AND LAND VALUES

The farm buildings usually comprise a well-built farmhouse, a barn for cattle and horses, haymow, grain cribs, hog houses, implement sheds, and chicken houses. There are on some farms granaries, haymows, separate cattle barn, sheep barns, and silos. According to the 1923 enumeration, there are 884 silos in the county.

The farming equipment usually includes corn planters, corn cultivators, disks, harrows, grain drills, end-gate seeders, self-binders, mowing machines, hayrakes, hay stackers, hay-mowing machinery, gang plows, manure spreaders, fanning mills, corn shellers, cream separators, and one or more automobiles. Less commonly included among the equipment are tractors, hay loaders, corn binders, trucks, and two-row cultivators. Certain implements such as corn shredders, silage cutters, threshing machines, hay balers, and corn pickers are owned in partnership or hired for use from an independent party. There were 275 tractors in 1923. Windmills or engine pumps are in common use, and there is good well water throughout the county. Barbed or combined barbed and woven-wire fences inclose nearly all the fields.

The labor expenditure for the year 1919 was $952.57 a farm. About two-thirds of the farms reported an expenditure for labor. All labor employed is white and chiefly American born. For the season of 1923 wage scales were about as follows: $35 a month when hired by the year, $45 a month summer wage, and $55 a month for the harvest season. Harvest hands were paid from $3 to $3.50 a day and corn pickers' pay averaged 6 or 7 cents a bushel. The labor

supply is usually adequate except during harvest and corn-picking time, when it is hard to obtain extra help.

Tenants operated 28.9 per cent of the farms in 1920. About two-thirds of the rentals were on a share basis and one-third on a cash basis or a share-cash combination. Share rentals range from one-third and two-thirds of the crops to one-half and one-half, depending on the equipment, livestock, and seed furnished by the tenants. Pasture and hay land rents at prices varying from $3 to $6 an acre. Cash farm rentals range in price from $5 to $11 an acre. The average size of farms was 164.5 acres.

Because there have been but few land transfers in the period following the World War, land valuations are difficult to make. Transfers of land in 1923 listed on the county deed register show an average value about $125 an acre.

SOILS

The soils of Olmsted County have developed from glacial and loessial materials under moderately humid climatic conditions. Leaching by percolating waters has been active for a long time, so that the lime carbonates and other soluble salts have been removed from the soil, to depths ranging from 3 to 5 feet. Below these depths, however, there are traces of lime carbonate, particularly in soils which occur in positions below limestone outcrops and which receive seepage waters from higher limestone areas.

Olmsted County is situated in that marginal belt in which the virgin forests of the East give way to the prairies of the West. Two types of vegetation exist here, the grassland prairies covering the broader stretches of undulating land, and the forested areas covering the steeper slopes, particularly along the valleys of the larger streams and their tributaries. The prairie soils have accumulated large quantities of organic matter which gives to such soils their characteristic dark-brown or black color, whereas soils of the forested areas are for the most part light brown in color, because there has been less accumulation of organic matter in the soil. The mature soils of this region may therefore be divided into two groups on the basis of the color of the topsoils, dark-colored soils of the prairies and light-colored soils of the forest areas.

The dark-colored prairie soils have dark-brown or black mellow topsoils, varying in texture from loamy sand to silt loam, to depths ranging from 12 to 20 inches. The upper part of the subsoil is brown, slightly heavier in texture than the topsoil, more compact and more granular, to depths ranging from 12 to 30 inches. Beneath this is light-brown or yellowish-brown material, heavier in texture than the upper part of the subsoil, and less compact. Upland soils having these characteristics are the Tama, Carrington, Thurston, and Dodgeville soils; and terrace soils, the Buckner, Waukesha, and O'Neill soils. These soils comprise about two-thirds of the land area of the county.

The most noticeable results of the weathering of these soils are the incorporation of organic matter in the topsoils, the concentration of fine soil particles in the upper part of the subsoil, and the leaching of lime to a depth of 5 feet. Because of droughtiness, soils of the

O'Neill and Thurston series have a thinner dark topsoil layer, which makes them less suitable for the growth of prairie grasses, and light-textured, loose subsoils developed from parent material containing loose sand and gravel, through which water percolates freely. Soils of the Buckner series have deeper topsoils, because they usually occur on low positions and have a higher water table and more abundant moisture supply. The same is true of soils of the Waukesha series.

Poor drainage has caused the mottled and gray color of the subsoils of the Muscatine and Sogn upland soils and the Clyde and Bremer terrace soils, and the moisture available in these soils has stimulated rank grass growth, resulting in deeper and darker topsoils. The same is true of the Wabash soils. Members of both the Wabash and Cass series are immature soils, and they cover about 75 square miles in this county.

The light-colored group, or forest soils, have a thin covering, from 1 to 3 inches thick, of dark-brown soil containing much organic matter derived mostly from forest leaf decay. To depths of about 15 inches, the topsoil varies in color from gray to light grayish brown, and in texture from loamy sand to silt loam, and is underlain by a 9-inch or 10-inch layer of grayish-brown material slightly more compact than the soil above. Below this, the subsoil is brown or light yellowish-brown, rather compact, heavy material, to depths ranging from 30 to 48 inches. Deeper yet is the yellowish-brown, friable material which is less compact than the subsoil. These soils are leached of lime to depths of 5 or 6 feet. Soils having these characteristics are the Clinton, Lindley, and Boone upland soils and the Sparta terrace soils, which cover about one-fourth of the county. The Boone and Sparta soils have developed under a condition of excessive subsurface drainage which has resulted in deeper and more thoroughly leached soil containing less organic matter and having less marked layers of concentrated fine soil particles than the Clinton and Lindley soils.

Olmsted County lies in that portion of Minnesota of pre-Wisconsin glaciation which is termed "the Old Gray Drift."[3] Soil-forming forces have been active upon parent-drift materials, and in some places the deep cutting of drainage waters has resulted in the thinning of the drift mantle and the exposure of underlying rock strata or subsoils developed over them.

There are rock bluffs along all major stream valleys. A total of about 20 square miles is thus classed as rough stony land. Associated with rough stony land are residual soils with subsoils developed over limestone, siliceous limestone, or sandstone. Of these, the Dodgeville soils developed over limestone under conditions of good drainage. These soils were originally prairie lands or land formerly forested but later covered with prairie vegetation. The Sogn soils developed over the most shaly limestone under conditions of poor drainage. The Boone soils developed over siliceous limestone or sandstone under conditions of excessive subsurface drainage. Orginially they were covered by a forest growth or a sparse growth of prairie grasses. These residual soils cover about 35 square miles.

[3] FRANK LEVERETT. SURFACE FORMATIONS AND AGRICULTURAL CONDITIONS OF THE SOUTH HALF OF MINNESOTA.

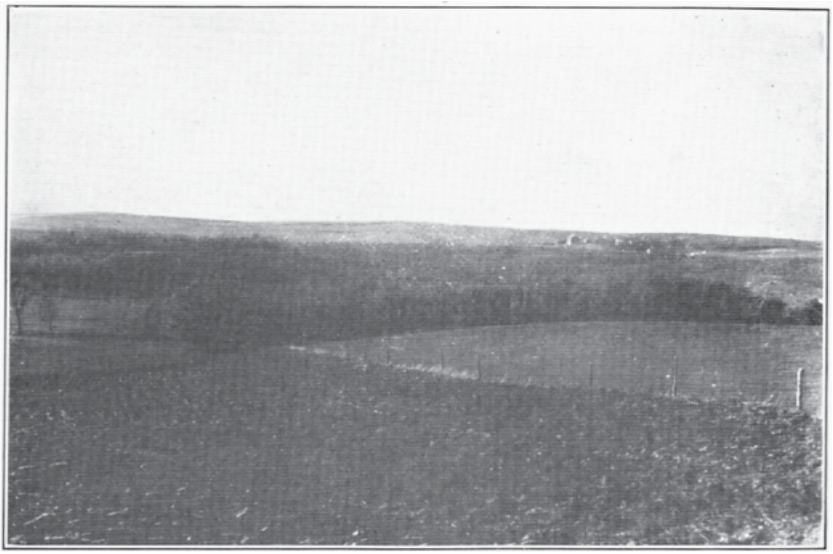

FIG. 1.—CHARACTERISTIC FEATURES OF THE UPLANDS OF OLMSTED COUNTY. THE SOILS ARE TAMA AND CLINTON SILT LOAMS

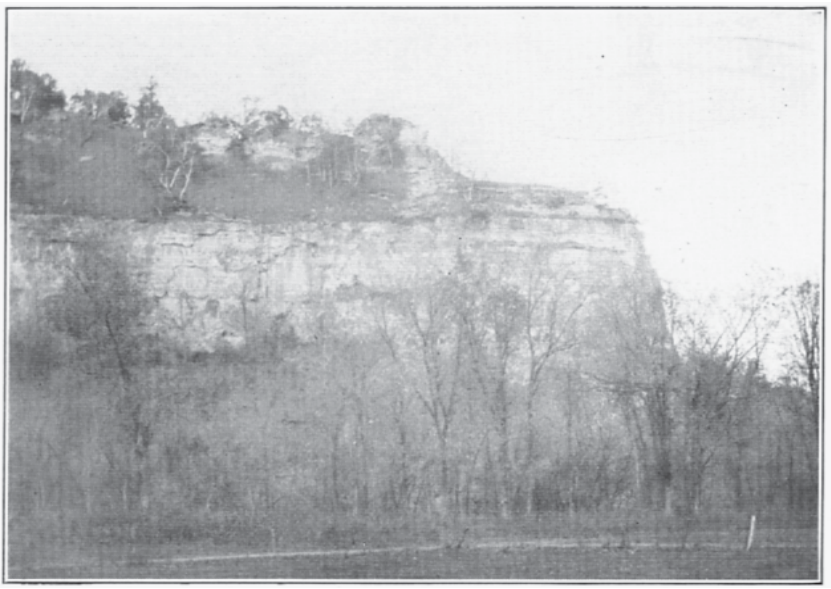

FIG. 2.—EXPOSURE OF LIMESTONE IN WHITEWATER CANYON IN THE NORTHEASTERN PART OF OLMSTED COUNTY

Soils formed from parent drift materials cover about 325 square miles. About two-thirds of this land originally was covered by prairie grasses. The Carrington soils have well-oxidized heavy subsoils developed under good drainage conditions. The Clyde soils have mottled, poorly oxidized, heavy subsoils developed under poor drainage conditions. The other third of the drift soil area was originally forested. These are the Lindley soils, which have well-oxidized, heavy subsoils developed under good drainage conditions. In some places these drift soils are so shallow that the underlying rock comes within 3 feet of the surface. These are shallow-phase drift soils. They cover about 50 square miles.

A little more than 250 square miles are covered by soils derived from wind-deposited materials. Originally this material, known as loess, was yellow or yellowish-brown silt with some clay and fine sand. It is believed that this material, before it was leached, contained much lime. Soil-forming agents have effected incorporation of organic matter in the topsoil, leaching of lime and other solubles to depths of 4 or 5 feet, and slight translocation and consolidation of clay particles in the subsoil. Of the total area in the county so covered, about four-fifths are prairie soils and one-fifth was originally forested. The Tama, Muscatine, and Bremer soils developed under prairie conditions, the former having good drainage and the latter two poor drainage. The Clinton soils developed under forest conditions, but in some places the forests have been superseded by sparse prairie growth.

The alluvial soils of the county cover about 90 square miles. They are classed, on the basis of age, formation, and position, into those on older and more elevated terraces and those on flood plains or first bottoms of more recent deposition. In general, the greater maturity of the terrace soils has resulted in a more thoroughly oxidized, more distinctly differentiated subsoil than that of the soils on flood plains.

The terraces vary in elevation from 10 to 50 feet above adjacent first bottoms, the higher soils being of glacial outwash formation and the lower of recent stream deposition. Their position below upland levels varies from 25 to 200 feet. Prairie growth predominated upon these terraces, and soil formation progressed under drainage conditions, varying from poor to excessive. The Buckner and Waukesha soils developed under good drainage conditions, the O'Neill soils under excessive drainage conditions, and the Bremer and Clyde under poor drainage conditions. The Sparta soils of the terraces developed under forest conditions or sparse prairie growth, and also under conditions of excessive drainage. The O'Neill and Sparta soils developed from sandier, coarser-textured terrace deposits which resulted in excessive drainage.

The soils on flood plains cover about 40 square miles. Very little of this land escapes periodic overflow. Two first-bottom soils are differentiated, as the Wabash soils, soils which have subsoils as heavy in texture as the topsoils and in some places heavier, and the Cass soils, soils which have subsoils lighter in texture than the topsoils. Both groups of soils are poor in lime.

The classes of soil mapped in the county are silty clay loam, silt loam, very fine sandy loam, loam, fine sandy loam, sandy loam, loamy

sand, and fine sand. Other classes on areas too small to be mapped are clay loam, silty clay, and sand. Silty clay loams cover about 20 square miles and are being developed under poor drainage conditions. Silt loams cover about 525 square miles, including about three-fourths of the upland soils, three-fifths of the terrace soils, and one-half of the bottom soils. Practically the entire loess soil area, about two-thirds of the drift-soil area, and about one-half of the residual-soil area are of the silt loam class. With the exception of about 10 square miles of silt loam developed under poor drainage conditions, this soil lies in positions where drainage has been favorable for the development of well-oxidized soils.

Very fine sandy loams cover slightly more than 1 square mile, and have developed under good drainage conditions on forested areas. Loam covers about 70 square miles, and has developed principally under drainage conditions favorable to heavy but well oxidized subsoil. A few areas are excessively drained. About one-seventh of the drift soils and one-third of the residual soils are loam, covering about one-tenth of the uplands, one-seventh of the terraces, and one-third of the first bottoms.

There are about 10 square miles of fine sandy loam on uplands where parent materials of drift or residual nature from sandstone and siliceous limestone have developed under drainage conditions varying from good to excessive. Areas of fine sandy loam on terraces and first bottoms are too small to be mapped. Sandy loam includes about 6 square miles of upland drift soil, 5 square miles of terrace soil, and 4 square miles of bottom soil. Loamy sand includes about 2½ square miles of upland drift soil and 2½ square miles of terrace soil. Fine sand occurs only on positions overlying bedded sandstone.

In the following pages the various soil types are described in detail. The table below gives the name, acreage, and proportionate extent of each soil type mapped in the county:

Acreage and proportionate extent of the soils of Olmsted County, Minn.

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Tama silt loam	121,792	28.6	Dodgeville loam	5,504	1.3
Carrington silt loam	83,584	21.6	Buckner silt loam	6,720	1.6
Shallow phase	8,512		Clyde silty clay loam	12,736	3.0
Carrington loam	10,432	2.9	Clyde silt loam	2,304	.5
Shallow phase	2,112		Waukesha silt loam	10,048	2.3
Carrington fine sandy loam	1,664	.4	Waukesha loam	1,984	.5
Clinton silt loam	49,216	11.9	Bremer silt loam	2,944	.7
Shallow phase	1,536		Bremer silty clay loam	1,728	.4
Clinton very fine sandy loam	1,216	.3	O'Neill loam	2,880	.7
Lindley silt loam	11,392	6.7	O'Neill sandy loam	2,816	.7
Shallow phase	17,216		Sparta loamy sand	2,048	.5
Lindley loam	5,184	2.3	Sparta sandy loam	896	.2
Shallow phase	4,603		Sogn silt loam, poorly drained phase	1,408	.3
Thurston sandy loam	3,456	.8	Wabash silt loam	12,608	3.0
Thurston fine sandy loam	1,728	.4	Wabash loam	6,912	1.6
Thurston loam	1,664	.4	Cass sandy loam	1,728	.4
Thurston loamy sand	1,920	.4	Rough stony land	10,496	2.5
Boone fine sandy loam	2,752	.6	Muck	2,880	.7
Boone fine sand	1,216	.3			
Muscatine silt loam	832	.2	Total	426,240	
Dodgeville silt loam	5,568	1.3			

TAMA SILT LOAM

Description.—The topsoil of Tama silt loam is very dark brown, mellow silt loam from 8 to 12 inches deep. Below this, to depths varying from 22 to 26 inches, is brown, heavy silt loam material, somewhat compact in places, underlain by brown or yellowish-brown, mellow, friable silt loam material. The subsoil is granular in structure, but becomes more cloddy with depth. To a depth of 4 feet the soil is leached of lime, but below this depth it is high in lime, and gray mottlings and iron stains appear.

Occurrence.—Tama silt loam is the most extensive soil of the county, its total area being 190.3 square miles. The largest area occurs on the uplands of Farmington, Haverhill, Viola, and Quincy Townships. Another extensive area includes the uplands of Elmira, Orion, Pleasant Grove, and part of High Forest Townships, with the exception of more rolling uplands adjacent to North Branch Root River and Mill Creek. A third tract of considerable size is near the town of Byron and extends east and north over a large part of the uplands of Kalmar and Cascade Townships. Smaller areas are well distributed over the county adjoining Carrington soils, or on less rolling land included with or adjacent to areas of Clinton and Lindley soils. The parent material is uniform and the soil occurs on undulating or gently rolling uplands. (Pl. 42, fig. 1.)

Variations occur on areas adjacent to Carrington and Lindley soils where there is gravel and coarse sand in the subsoil and the texture ranges from clay loam to silty clay loam, more plastic and more granular in structure. Where it adjoins areas of Lindley and Clinton soils the topsoil is lighter colored than typical and of less depth, and the land is more rolling. On small tablelike areas the depth of the soil ranges from 4 to 10 feet, and is underlain by limestone. Usually, however, Clinton and Lindley soils occur in positions between the outcrop slopes of bedrock and the deeper Tama silt loam area.

Tama silt loam also occurs on foot slopes of bedrock outcrops and extends over less elevated uplands, which in some places have the tablelike appearance of outwash terraces. A few such areas appear to be loess-mantled outwash plains on which, in some places, the substratum of gravelly sandy drift lies within 3 or 4 feet of the surface, as in sections 5 and 6 of Quincy Township. In section 7 of the same township is an elevated table-land capping bedrock slopes. On lower upland drainage-way slopes the topsoil of Tama silt loam is deeper than that of typical black mellow silt loam and continues to a depth of 2 or more feet.

General conditions.—Surface and subsurface drainage of Tama silt loam is well distributed. The drainage ways occur at regular intervals and have sufficient fall for good run-off. Surface drainage is nowhere excessive to the point of causing damage by erosion. Practically all of this soil is utilized for agricultural purposes and probably a greater proportion of it is under cultivation than of any other soil of the county. Under cultivation it is planted to corn and small grains more than most of the other soils.

Crops and animal products.—The main crops grown on this soil are as follows: Corn, oats, clover and timothy hay, and barley, named in order of their acreage. There is practically no waste land on

areas of this soil, and very little forested pasture or wild-hay meadows. Hog raising is the most important livestock industry. Dairying ranks second in importance and beef production third. The raising of horses, sheep, and poultry is of minor importance.

All crops common to the county produce well on this land. Corn averages about 45 bushels an acre, or for silage about 10 or 12 tons an acre; oats yield 35 bushels; barley, from 25 to 30 bushels; wheat, 20 bushels; flax, from 10 to 15 bushels; timothy and clover, mixed, 2 tons of hay; timothy alone, from 1½ to 2 tons; clover alone, from 2 to 2½ tons; and alfalfa, from 2½ to 3 tons.

On account of its mellow topsoil and well-drained subsoil, Tama silt loam is easily maintained in a good state of cultivation. It can be worked under a moderately wide range of moisture conditions. The general practice is to fall plow stubble fields to which applications of manure have been added. Often, however, plowing is delayed until spring. Ordinarily, corn and small grains are continuously cropped from three to six years before seeding down for hay meadow. Hay is cropped for two years and maintained in pasture sometimes for two years more before the field is again broken for grain. Only occasionally are systematic rotations with cultivated hay grasses followed, but the practice is slowly gaining in favor.

Farms and land values.—Farms on Tama silt loam are well equipped with such buildings as the industries of the farm demand (pl. 42, fig. 1), and reflect the productiveness of the soil. The land transfers during 1923 showed a range in value from $75 to $200 an acre, averaging about $125 an acre.

Suggestions.—The practice of systematic crop rotation is to be recommended rather than the more prevalent grain-cropping practice. Applications of manure also should be increased as a means of maintaining productiveness.

CARRINGTON SILT LOAM

Description.—Carrington silt loam, to a depth of about 12 inches, consists of dark-brown or black, mellow silt loam, rather high in organic matter, underlain by brown, heavy silt loam or silty clay loam material, granular and slightly compact. Between depths of 24 and 34 inches, the material is yellowish-brown silty clay, mottled with gray, and is plastic when wet but cloddy when dry. Below a depth of 34 inches, the drift material is more sandy and gravelly and varies in texture. Some sand and gravel is present in the topsoil and some bowlders are on the surface and throughout the soil. This soil has developed over drift deposits on undulating or gently rolling uplands where drainage is good and where the subsoils are well oxidized and contain organic matter from decayed prairie grass.

Occurrence.—This soil covers about 115 square miles in Olmsted County. Extensive upland areas of it include the larger part of Rock Dell, Salem, and Dover Townships, the south half of High Forest Township, the east half of Eyota Township, the southwestern part of Oronoco Township, and the northeastern and eastern parts of New Haven Township. In other parts of the county areas are more scattered and more closely associated with other upland soils. Where this soil adjoins areas of Tama and Clinton silt loams, it

usually occurs on slopes below them. It also occurs on occasional elevated knolls.

The topsoil of Carrington silt loam in many places is more uniform in texture than typical, and on areas adjoining Clinton silt loam, is slightly lighter colored. Where it adjoins Lindley silt loam, Carrington silt loam differs only in its dark-colored topsoil. Boundaries between the two are arbitrary in many places, and some comparatively light-colored soils are included with Carrington silt loam as mapped. Carrington silt loam, in sections 1 and 2 of New Haven Township, shows this lighter-colored topsoil which is generally shallower in depth than that of typical Carrington silt loam.

Where it adjoins its shallow phase and other residual soils, Carrington silt loam is in positions either above or below them. In section 13 of Rochester Township, this soil occurs on uplands occupying positions lower than shallow phase soils, whereas in section 17 of Rock Dell Township areas are mapped where it occurs above shallow phase rims bordering the drainage.

Where it adjoins areas of Carrington loam and Carrington fine sandy loam, this soil usually is on lower, more level positions, with coarser-textured soils above. In the vicinity of the Thurston soils, which have lighter-textured subsoils, its subsoil is lighter than typical in texture.

Here and there, areas of this soil occur as broad, depressed drainage valleys, where the soil is deeper than typical, in some places closely resembling Buckner silt loam except that the Buckner soil contains more sand and gravel, as in sections 4 and 8 of New Haven Township. In other places there are areas on nearly level, lower uplands resembling outwash terraces, covered with unassorted drift materials, as in section 28 of Farmington Township.

General condition.—This land is undulating or gently rolling, more level areas occurring in the southern half of Rock Dell Township and elsewhere in isolated terracelike positions or valley-filling areas. The more rolling land is shown in sections 1 and 2 of New Haven Township. On slopes, bodies of this soil are never severely eroded. Under normal moisture conditions, surface drainage is usually adequate and subsurface drainage is well suited for the production of crops. Carrington silt loam is an important soil agriculturally. Practically all of it is under cultivation, only a very small proportion being scantily wooded pasture land.

Crops and markets.—This is the most heavily cropped soil in the county, all staple field crops of the region being raised and ranking in acreage about as follows: Corn, oats, clover and timothy hay, barley, flax, rye, potatoes, and buckwheat. Stewartville, in the heart of the larger expanse of this soil, is the principal local grain market. A smaller proportion of the grain raised is fed on the farms in this vicinity than on those of other sections.

Crop yields are somewhat higher than on other soils of the county, yields of corn varying from 40 to 50 bushels an acre; oats, from 30 to 45 bushels; barley, from 25 to 30 bushels; flax, from 10 to 16 bushels; rye and wheat, each about 20 bushels; clover and timothy hay, from 2 to 2¼ tons; timothy alone, 2 tons; clover alone, from 2 to 2½ tons; and alfalfa, from 2½ to 3 tons.

Carrington silt loam is easily maintained in good tilth, and may be worked under a reasonably wide range of moisture conditions. Fall plowing for corn is generally practiced when labor and seasonal conditions allow, but when more pressing duties interfere plowing is done in the spring. Corn, small grain, and hay stubble, with applications of manure when available, are plowed under. Cropping to corn and small grains is usually practiced for from 4 to 8 years before seeding the land to hay meadow. The land is retained in hay and pasturage meadow for from 2 to 4 years; then is again cropped to grain.

Systematic crop rotations are slowly increasing in favor, however, the most common of these being corn one year, small grain one year, clover and timothy two years.

Animals and animal products.—Livestock enterprises receive considerable attention. Most farmers keep more hogs than cattle. Dairying ranks next in importance, followed closely by beef production. Good draft horses are kept and colt production usually supplies local demands. Sheep raising for wool and mutton is of some importance and poultry is kept on all farms.

Farms and land values.—The average farm on Carrington silt loam is well improved. Land transfers during 1923 showed a range in value from $90 to $240 an acre, and averaged $120 an acre. This value is rather less than normal market levels.

Suggestions.—The more prevalent practice of crop rotation and the use of larger quantities of manure as fertilizer are the principal means of improving and maintaining soil productivity.

Carrington silt loam, shallow phase.—Shallow Carrington silt loam consists of dark-colored silt loam material formed from drift parent material, underlain by bedrock at depths varying from 2 to 5 feet. There is a variety of subsoils in different areas of the shallow phase as mapped. Where the soil is deeper, it closely resembles that of typical Carrington silt loam to within a few inches of bedrock, where there is concentration of clay particles in the subsoil. This compact, finer-textured material resembles that of the typical residual subsoil of the Dodgeville soils, but in most cases its slight degree of compactness indicates a concentration of clay from the soil above rather than a weathered product of the bedrock.

The presence of drift sands and gravel at greater depths in the subsoil, the absence of plastic, compact material over the bedrock, and the smaller degree of consolidation of subsoil materials, are characteristics of Carrington silt loam, shallow phase, which distinguish it from Dodgeville silt loam. These shallow phase soils lie on elevated upland positions over horizontal bedrock, also on slopes overlying outcrops of bedrock strata. Ordinarily on areas over the horizontal bedrock, the soil of this phase is deeper, but on slopes it is shallower.

The largest area of this shallow soil is in section 28 and adjoining sections of Rochester Township. Here the land is undulating with but little drainage dissection, but the slope is sufficient to maintain favorable moisture conditions except in extremely wet periods. The remaining areas of this soil are small and widely distributed.

Areas of this soil on slopes vary from gently to abruptly sloping, and extend toward both deep and shallow valleys. Ordinarily the

height and degree of these slopes are not so great as those on which Lindley silt loam, shallow phase, occurs.

Natural drainage is well established. Internal drainage, although retarded by the bedrock, finds a ready outlet over the rock to seepage slopes.

Nearly 14 square miles in Olmsted County is covered by Carrington silt loam, shallow phase. From one-fourth to one-third of this land is cultivated and the remainder is in forest or wooded pasture lands. Cropping practices and methods of cultivation are similar to those for Dodgeville silt loam. Crop yields are about the same on the two soils. Land values average a little higher than those of Dodgeville silt loam.

CARRINGTON LOAM

Description.—Carrington loam, to a depth of about 12 inches, consists of dark-brown mellow loam underlain by slightly compact brown silty clay loam material, granular in structure, which continues to a depth of 20 or 24 inches. Below this is friable yellowish-brown, silty clay loam material with variable amounts of sand and gravel. When wet, the topsoil is slightly plastic, and the subsoil is very plastic; both are sufficiently retentive of moisture. This soil is formed from glacial upland deposits of moderately fine and uniform texture, and there are some bowlders on the surface.

Occurrence.—The total extent of Carrington loam in Olmsted County is about 16 square miles. It occurs on undissected high divides and on upland drainage slopes. In most places it adjoins other glacial soils, less frequently residual soils, and least frequently loess soils. It usually occurs on positions above upland areas of drift silt loams and below areas of fine sandy loam and loamy sand drift soils.

Carrington loam generally lies on eroded slopes below adjoining areas of loess. The subsoil is neither so heavy nor so uniform in texture as is that of silt loam, especially where areas of loam are adjacent to lighter subsoil drift soils of the Lindley and Thurston series. Carrington loam is a little lower in organic matter than is Carrington silt loam and as a consequence is not so dark colored. The lighter-colored topsoil of Carrington loam usually is present in areas which border bodies of Lindley and Clinton soils.

General condition.—This land is gently rolling and rarely includes abrupt slopes, but some of the elevated divide positions are narrow crested. This land is less rolling than areas of Lindley soils and more rolling than those of Carrington silt loam.

Natural drainage is well established. Where the subsoils are lighter and the land more rolling, drainage is sometimes excessive and crops suffer in long periods of dry weather. This soil, as a whole, however, is not considered droughty.

Originally the growth was prairie grasses, with some trees. Most of this soil is cultivated, the remainder being in wooded pasture lands and small forested areas. Under cultivation this soil is not so continuously cropped to corn and small grains as is Carrington silt loam; proportionately more land is devoted to small grains; and a greater proportion is kept in hay and pasture meadows. Crop yields

on the two soils average lower in dry years and about the same in wet years.

Carrington loam may be worked under a wide range of moisture conditions and seed beds usually may be prepared a little earlier in the spring than is practicable on silt loam. The supply of organic matter is less and more frequent or heavier applications of manure are necessary to maintain fertility.

Land values.—Land values rank lower than those of Carrington silt loam. Transfers of land on record for 1923 showed an average selling price between $75 and $100 an acre.

Carrington loam, shallow phase.—Carrington loam, shallow phase, consists of dark-brown loam varying in texture and in the quantity of coarser sands and gravel it contains, and underlain by bedrock at depths ranging from 2 to 4 feet. This soil differs from Dodgeville loam in that the latter has heavy subsoil material developed over underlying rock and has less drift sand and gravel throughout the soil.

Areas of this soil total about 3 square miles, the largest two occurring on elevated plateaulike positions overlying horizontal bedrock and on slopes overlying outcropping bedrock. Areas on slopes are generally associated with surrounding drift soils of lighter texture, and in some places with loess and residual soils. The slopes border drainage ways, buttes, or abrupt elevations at some distance from drianage dissection, and ordinarily are not more than 75 feet high. The degree of slope ranges from gentle to abrupt.

The larger areas lie chiefly in Marion and Rochester Townships. The bedrock is a little deeper than on slope areas, and the soil is not so varied in texture by slope-wash modifications. Probably about one-fourth of the acreage of these larger areas is cultivated, the remainder being in forest or wooded pasture lands. Cropping practices and methods of treating the soil under cultivation conform rather closely to those used on Dodgeville loam, and crop yields on the two are about the same. Methods of improvement for Dodgeville loam apply equally well to this soil. Land values of the shallow phase of Carrington loam can not well be determined because of its comparatively small areas and scattered distribution. Cultivable areas, however, command values somewhat lower than those of typical Carrington loam.

CARRINGTON FINE SANDY LOAM

Description.—Carrington fine sandy loam consists of brown, fine sandy loam, about 10 inches deep, underlain by brown sandy clay loam material, compact in places, to a depth of 24 inches. Below this is friable yellowish-brown material which ranges in texture from sandy clay loam to sandy clay. The parent material is upland drift, a little coarser in texture than that from which Carrington silt loam has developed. The topsoil contains some organic matter, and the subsoil is not so dry as the topsoil. Carrington fine sandy loam is droughty during periods of low rainfall, but it is not so droughty as soils of the Thurston series which it adjoins in some places.

Occurrence.—The total extent of Carrington fine sandy loam in Olmsted County is 2½ square miles, two-thirds of which is in Marion

Township where the soil occurs on upland divides on a level with the Thurston and Carrington soils and on slopes below them. Small areas are scattered throughout the county, usually on small slope strips or on rather abrupt elevations above the adjoining soils. In some places this land adjoins areas of shallow-phase soils and is underlain by bedrock at depths varying from 2 to 4 feet, as in section 11 of Rochester Township.

General condition and crops.—Most of this land is gently rolling or rolling, but some of it is more abruptly sloping. Surface drainage is excellent and underdrainage is well established, except during long dry periods.

In Marion Township most of this soil is under cultivation, but the small areas elsewhere are not cropped except where they are closely associated with other cultivated soils. A small part is occupied by forest growth, and the associated grassland is utilized for pasture.

Among the grain crops corn and rye yield the highest returns. In wet seasons yields of oats and barley are fairly good, but dry weather usually reduces the production of these crops because of the tendency of this soil toward droughtiness. Hay crops likewise usually are short in dry seasons. Crop yields generally are a little higher than those obtained on Thurston fine sandy loam or Thurston loam. Frequent or heavy applications of manure are recommended.

CLINTON SILT LOAM

Description.—To a depth varying from 6 to 8 inches Clinton silt loam consists of dark grayish-brown, mellow silt loam containing organic matter incorporated from the thin covering of forest leaf mold. This is underlain by light grayish-brown or nearly gray mellow silt loam material, to a depth of about 14 inches. Below this is grayish-brown, heavy silt loam material, granular in structure and having some concentration of fine soil particles, to a depth of about 24 inches, below which the material becomes more compact and cloddy. The lower part of the subsoil is yellowish-brown, friable silt loam material which continues to a depth of 5 or 6 feet and becomes more sandy with depth.

Occurrence.—Areas of Clinton silt loam in Olmsted County total nearly 80 square miles. The largest areas occur on rolling land adjacent to the main drainage ways of Orion, Viola, Quincy, Elmira, New Haven, and Pleasant Grove Townships, and smaller tracts occur throughout the county.

Where this soil adjoins the Tama soils the land is rolling, with drainage dissection at less frequent intervals but of greater depth. This soil generally borders the larger streams and drainage ways, whereas Tama silt loam is usually farther away from such drainage dissection. Where it is surrounded by Tama silt loam, this soil is usually on narrower-capped higher divides and steeper slopes. Where Clinton silt loam borders Carrington silt loam, it occurs on elevated divide crests above Carrington silt loam.

Clinton silt loam is most closely associated with the Lindley soils, which occur on similar rolling, elevated lands of deeper and more thorough dissection by drainage ways. The color of the topsoil is similar, but the texture of Clinton silt loam is more uniform, and the

subsoil is more friable and is practically free from the drift sand and gravel which are characteristic of the Lindley soils. Where it borders Lindley soils, the subsoil of Clinton silt loam, at a depth of 2 feet, consists of glacial drift containing sand and gravel.

Where this soil borders its shallow phase or residual soils which rest upon bedded limestone and outcrop slopes, it occurs on elevated positions above them, and is usually slightly dissected by drainage ways. In such locations the subsoil is sometimes slightly more compact than is typical and has gray stains instead of the solid yellowish-brown color of typical Clinton silt loam.

General condition.—Areas of this land are gently rolling or rolling and are usually adjacent to the main drainage systems of the county. A very small area is very steep, but in general the slope is sufficiently gentle to make cultivation practical. Such areas are well developed in Elmira Township, where Clinton silt loam occurs on steep slopes between the higher and lower levels of upland, or where it borders deeply dissected drainage ways. However, soils on steep slopes included with bordering Clinton silt loam are shallow-phase soils over outcropping bedrock.

Areas of Clinton silt loam are well dissected by drainage ways, and surface drainage is everywhere adequate and in some cases is excessive. Subsurface drainage is good and the soil maintains favorable moisture conditions in normal seasons. In exceptionally dry years, however, the more rolling land is droughty.

Clinton silt loam may be plowed under a wide range of moisture conditions and is rather easily maintained in good tilth. It has less tendency to clod than has Tama silt loam, is lower in organic matter, and needs heavier or more frequent applications of manure. Crops mature earlier, as the land can usually be prepared for plantings a little earlier in the spring. Fall plowing, therefore, is not so great an advantage on Clinton silt loam as on Tama silt loam, but the practice is generally considered best when possible.

Clinton silt loam originally supported a good growth of hardwood forest. At the present time about one-half of this land is forested, with a sparse pasture grass undergrowth. Approximately one-sixth is in less densely wooded pasture lands. The remainder is under cultivation.

Crops.—On cultivated areas the acreage in small grains is almost as large as that in corn, and the production of small grain is considered more satisfactory than that of corn. Cropping to grain is not so continuous as on Tama silt loam and acreages of clover and timothy are greater.

Corn yields average about 35 bushels an acre; oats, 40 bushels; barley, 25 bushels; rye, 20 bushels; wheat, 15 bushels; flax, 10 bushels; timothy and clover hay, 1¾ tons; clover alone, 2 tons; timothy, from 1½ to 1¾ tons; and alfalfa, 3½ tons.

Animals and animal products.—Although hogs are kept in greater numbers than cattle, cattle raising is scarcely less important on farms on this soil. Dairying receives about as much attention as does beef production. The work animals kept are good draft horses, and the farmers usually raise enough colts to supply their farm demands. Sheep raising for both wool and mutton production is of minor importance, as is also the poultry industry.

Land values and suggestions.—Most farms on Clinton silt loam are well improved. Land transfers in 1923 showed a range in value from $60 to $115 an acre, with an average of $90 an acre. These figures are probably less than normal market values.

More common adoption of systematic crop rotation and heavier and more frequent applications of manure are necessary if the fertility of Clinton silt loam is to be maintained.

Clinton silt loam, shallow phase.—Clinton silt loam, shallow phase, consists of light-brown silt loam of fairly uniform texture resting on bedrock at a depth ranging from 2 to 5 feet. This soil deposited upon the bedrock is of loess origin and was previously deep, but is now eroded to its present depth. In only a few places does a weathered thin residual soil layer overlie the rock, and in these places the soil is freer from modifications of residual subsoil material than in other shallow-phase areas. Here and there the soil resembles Lindley silt loam, shallow phase, but it is more uniform in texture and is comparatively free from sand and gravel.

The only large area of this soil in the county occurs in section 22 of Rochester Township, where it borders Carrington silt loam, shallow phase. The transition to the darker color and greater content of drift material of the Carrington soil is very gradual. About 50 per cent of this land is cultivated, and the remainder is in forest and native pasture land. Farming practices are similar to those employed on the typical soil. Yields are about the same, or perhaps are slightly lower than on the typical soil. The remainder of this soil occurs on parts of slopes above precipitous outcrops and is all in forest growth. The shallow phase of Clinton silt loam covers an area of about 2½ square miles.

The following table gives the results of mechanical analyses of two samples of the topsoil and two of the subsoil of typical Clinton silt loam:

Mechanical analysis of Clinton silt loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
321386	Topsoil, 0 to 2 inches	0.2	2.1	1.5	6.4	12.8	67.4	9.6
321387	Topsoil, 2 to 6 inches	.2	.4	.4	2.1	18.8	67.1	10.6
321388	Subsoil, 6 to 15 inches	.0	.0	.4	5.4	20.4	62.1	11.3
321389	Subsoil, 15 to 36 inches	.0	.0	.4	6.5	26.6	56.4	10.1

CLINTON VERY FINE SANDY LOAM

Description.—The topsoil of Clinton very fine sandy loam is light-brown or dark yellowish-brown very fine sandy loam, 15 inches deep. The subsoil is yellowish-brown, slightly compact silt loam material underlain by pale yellowish-brown or yellow, friable material of silt loam texture, containing a small percentage of very fine sand. The topsoil is open and less retentive of moisture than the subsoil, which is moderately plastic when wet but compact when dry. Favorable moisture conditions prevail except during dry seasons. The soil usually is well oxidized and low in lime.

The loessial material over which Clinton very fine sandy loam developed is a little coarser than that over which Clinton silt loam developed. Where areas adjoin Lindley soils the subsoil is less uniform in texture than is typical and contains small quantities of coarse sand and gravel. In some places this soil is underlain by bedrock at a depth varying from 2 to 5 feet, these shallower areas being adjacent to other shallow soils on level uplands or on outcrop drainage slopes which are mapped with this soil. Such variations occur in sections 21 and 22 of Rochester Township.

Occurrence.—About 2 square miles in Olmsted County are covered by Clinton very fine sandy loam, areas occurring in Salem, Rochester, and Oronoco Townships.

General conditions.—This land is rolling and occurs in positions similar to those of Lindley silt loam and Clinton silt loam, which it adjoins. Surface drainage usually is excessive, but erosion is not active. Subsurface drainage is well suited to normal seasons but is too active for dry seasons. More than half of this land is in forest or wooded pasture lands. The broader crests and less rolling areas are cleared and cultivated. Farming methods are similar to those described for Clinton silt loam, but yields are a little lower, and the market value of the soil averages less.

LINDLEY SILT LOAM

Description.—Lindley silt loam consists of brown, mellow silt loam, about 12 inches deep, underlain by yellowish-brown, friable, well-oxidized material, varying in texture from clay loam to silty clay loam and containing small quantities of sand and gravel which increase with depth. Below this is brown or yellowish-brown, compact, silty clay loam material, varying in structure from granular to cloddy. The soil has developed from glacial-drift material under a forest cover.

Occurrence.—Lindley silt loam is well distributed over Olmsted County, most of it adjoining other drift soils. The largest areas are in New Haven, Salem, Dover, Kalmar, and Rock Dell Townships, others being in Farmington, Viola, Quincy, and Marion Townships. Lindley silt loam occurs on high, rolling drift uplands, usually where they adjoin deeper dissected stream valleys; but in some places, where this soil borders Carrington silt loam and Thurston silt loam, are areas isolated within the drift plain and separated from any important drainage way.

Some small areas of Lindley silt loam border Clinton and Tama soils and generally occur on drainage slopes below them. In some places the color of Lindley silt loam resembles that of Carrington silt loam, but as this is true only of a thin surface layer it may be a result of the incorporation of organic matter by cultivation. This variation usually occurs on slopes below areas of Carrington and Tama soils. Where this soil adjoins lighter-colored Thurston soils it contains the largest quantity of coarse-textured sands and gravel. Where areas border Clinton soils the depth of the fine-textured topsoil varies so that it is difficult to distinguish between the Lindley and the Clinton soils. Where quantities of sand and gravel occur at

a depth of 2 or more feet, the soil has been classed with Lindley silt loam, and where these are not present, with Clinton silt loam.

General condition.—This land is gently rolling or rolling and, except for isolated areas on ridges, is dissected by established drainage ways.

Drainage is well established for the maintenance of favorable moisture conditions except on the more rolling land and where the subsoil is lighter.

Originally this land was forested with hardwoods common to this region, and perhaps from two-thirds to one-half of its area is at present in forest or sparsely forested pasture lands. Under cultivation it yields good returns of all the crops of this region. Farming methods and general crop adaptations are similar to those used on Clinton silt loam, and recommendations made for Clinton silt loam apply equally well to Lindley silt loam. Land values of the two soils are about the same.

Lindley silt loam, shallow phase.—Lindley silt loam, shallow phase, comprises areas where bedrock lies within 2 feet of the surface and crops out in places. The soil generally has a light-colored silt loam topsoil with a well-oxidized, clay loam subsoil underlain by bedrock, and containing glacial sand and gravel.

A total area of nearly 27 square miles is covered by Lindley silt loam, shallow phase. About five-sixths of this land is on slopes where the bedrock is but thinly covered. These slopes border drainage ways which dissect drift-soil areas and in some places those which dissect loess-soil areas. Where this shallow phase adjoins silt loams of loessial origin it contains few glacial sand and gravel particles. In some places a thin layer of residual soil, more plastic and heavier in texture than is typical, immediately overlies the bedrock. Still another variation of Lindley silt loam, shallow phase, is that which occurs above sloping outcrops and between them and the deeper soils of the smooth upland. The degree of slope ranges from gentle to moderately steep, and the height from 25 to 200 feet.

Surface drainage is excessive, but the land seldom erodes rapidly except on slopes where vegetation is most scanty. The majority of the slopes are heavily forested with trees common to the county, and have a scant grass cover. The narrower strips have more scattered forest growth and heavier grass sod, and furnish good pasturage except during dry periods. None of the slope areas are utilized for crops, but are kept in forest, pasture land, or a combination of the two. As the soil is subject to erosion if the vegetative cover is disturbed, the most practical method is to retain the native vegetation.

There are a few broad stretches of the shallow phase of Lindley silt loam above outcrop slopes and below the deeper soils of adjoining upland levels, in sections 11, 15, and 20 of Rochester Township, section 6 of High Forest Township, and section 12 of Cascade Township. This land varies from level to undulating, roughly conforming to the underlying rock-bed stratum. Parts of these areas are cultivated and crop yields are fairly good in seasons of normal rainfall, but dry seasons result in crop losses. Thorough cultivation, deep plowing with frequent tillage, and the incorporation of organic matter in the form of manure and crop residues are beneficial and essential to best returns.

The land value of this soil is difficult to estimate, but the cultivable areas of Lindley silt loam, shallow phase, probably rank almost as high in price as areas of Dodgeville silt loam.

LINDLEY LOAM

Description.—Lindley loam consists of light-yellowish or grayish-brown loam to a depth of about 12 inches, underlain by brown, compact, silty clay loam material to a depth of about 28 inches. This in turn is underlain by yellowish-brown material, varying in texture from clay loam to silty clay loam, and containing pebbles, coarse sand, and small glacial bowlders. The subsoil is well oxidized and friable but moderately plastic when wet.

The soil has developed from well-weathered glacial-drift material on the uplands. It borders areas of Carrington loam and Carrington silt loam, from which it differs principally in having a lighter-colored topsoil; Clinton silt loam, from which it differs in having a loamy topsoil and less uniformly textured subsoil free from coarse sands and gravel; Dodgeville loam, from which it differs in having a lighter-colored topsoil, deeper unweathered subsoil containing large quantities of drift sand and gravel, overlying bedrock; and Thurston loam, from which it differs in having a heavy-textured water-retentive subsoil.

Variations occur where the soil closely resembles soil which it borders. In many places it is difficult to distinguish boundaries between this and Carrington soil, but Lindley loam includes only soils which are distinctly light in color.

Occurrence.—The total area of Lindley loam in Olmsted County is about 8 square miles, which includes patches of fine sandy loam too small to be mapped separately. It is well distributed throughout the county. The majority of the areas are small; the largest are in section 33 of Rochester Township, section 6 of Oronoco Township, section 2 of Kalmar Township, sections 15 and 20 of Eyota Township, and section 4 of Elmira Township. These areas are on slopes either above or below uplands where there is silt loam and loam, on rather narrow-crested elevations in adjacent uplands or terraces, and even in stream valleys.

General condition.—This land is gently rolling or rolling. Surface and subsurface drainage are both well established. Few of the slopes are so steep as to result in erosive surface drainage. Originally this land was forested with oak, maple, ash, poplar, basswood, elm, and some other trees. About one-fifth of it is still in forest.

The cropping practices and methods of cultivation are similar to those described for Carrington loam; however, because Lindley loam has less organic matter, cropping is not so continuously followed and applications of manure usually are greater and more frequently applied. Land values are the same as or a little lower than for Carrington loam.

Lindley loam, shallow phase.—Lindley loam, shallow phase, occurs on slopes where the soil is only about 2 feet deep, or even less, and is underlain by bedrock. This soil is generally light colored, variable in texture, and contains considerable sand and gravel. The bedrock is covered, except in a few places on the slopes. Sparse grass

growth or forest growth covers most of the slopes and prevents erosion from further exposing of the bedrock.

Areas of the shallow phase of Lindley loam total about 7 square miles, and occur throughout the county. The degree of slope varies from gentle to steep, but is never precipitous. The slopes usually range from 25 to 150 feet in height, but in a few places are higher. This land is almost entirely in pasture and forest. Where forest growth is entirely lacking the natural pasture growth is usually too sparse to support a sod, and some erosion has taken place. Seedings of pasture grasses are recommended to maintain a cover crop.

A few areas of the shallow phase of Lindley loam occur on upland crests which are almost level or only gently rolling. These areas extend upward from bedrock outcrops on adjacent slopes, as in section 6 of High Forest Township, section 6 of Haverhill Township, section 14 of Eyota Township, and section 30 of Rochester Township. Parts of these tracts are cultivated but crop yields are only fair, as droughtiness, lack of organic matter, and a shallow root zone hinder production. Crop yields are about the same as those on Dodgeville loam, and recommendations for the improvement of Dodgeville loam apply equally well to the cultivable areas of Lindley loam, shallow phase.

THURSTON SANDY LOAM

Description.—The topsoil of Thurston sandy loam is dark-brown, friable sandy loam, from 12 to 15 inches deep, and the subsoil is brown porous sand or loamy sand material, and usually contains some gravel. In some places the subsoil consists almost solely of beds of indistinctly stratified gravel. The parent material is coarser-textured glacial-drift material. The soil material, as a rule, is deep, but in section 19 of Eyota Township there is an area of this soil which is shallower than typical, the bedrock being within 3 or 4 feet of the surface.

Occurrence and general condition.—This soil covers an area of nearly 6 square miles in the county. It is widely distributed over those parts of the county where glacial soils are found. The larger areas occur principally in the Bear Creek region, from 3 to 8 miles southeast of Rochester, where this land is undulating or rolling with no conspicuous hillocks or hummocks. On smaller areas in other parts of the county, the land in most places is sharply rolling, with abrupt hillocks and knobs.

On larger areas where the land is smoother, gravel is rarely present in the subsoil to a depth of 3 feet; but on smaller isolated areas where there are kames, the subsoil is very gravelly and is a source of gravel for road construction.

Surface drainage is well established, and underdrainage varies from good to excessive. The soil, as a whole, is droughty.

Thurston sandy loam is not an important agricultural soil in the county, and only about 60 per cent of it is cultivated. Most of the remainder is in woodland. The principal trees are oak, maple, and ash.

Crops and land values.—Almost all staple crops are grown on this soil, with only fair success in dry years. Corn yields average about 25 bushels an acre and rye between 15 and 25 bushels. The soil is

fairly well adapted to small fruits and truck crops, which are grown for local use. Land values for this soil during 1923 averaged about $50 an acre.

Suggestions.—Retention of organic matter in this soil is important, and may be accomplished by frequent applications of manure, plowing under of cover crops, and deep, thorough tillage.

THURSTON FINE SANDY LOAM

Description.—Thurston fine sandy loam consists of light-brown or brown friable fine sandy loam, varying in depth from 8 to 12 inches, underlain, to a depth of 36 inches by light-brown or yellowish-brown, porous, loamy sand, which in places contains layers of stratified gravel. The soil is developed from sandy and gravelly upland drift deposits, slightly assorted by water action, and is much less uniform in texture than the Sparta soils of glacial outwash terraces, which it adjoins. A variation of this soil, shallower than typical Thurston fine sandy loam, occurs in section 20 of Eyota Township, where bedrock appears within 2 or 3 feet of the surface.

Occurrence.—Thurston fine sandy loam covers a total area of about 3 square miles in the county, occurring in a few areas west and south of Eyota.

General condition and crops.—This land is undulating or gently rolling. Surface drainage is well established and underdrainage varies from good to excessive, the coarse texture and open structure of the subsoil causing the soil to be droughty.

This land is not important agriculturally. About 40 per cent of it is cultivated, and the remainder is forested, principally with oak, maple, and ash.

Yields of staple crops are fairly good in favorable seasons. Early maturing crops are the most successful, however, as the soil does not retain moisture in sufficient quantities for continued growth, especially of shallow-rooted crops, during ordinary drought. Corn and winter rye are the most successful crops grown.

THURSTON LOAM

Description.—The topsoil of Thurston loam consists of brown or dark-brown friable loam, from 12 to 15 inches deep. The subsoil, to a depth of about 40 inches, is yellowish-brown or light-brown material, ranging in texture from sandy loam or loamy sand containing considerable fine gravel to feebly stratified gravel of great thickness. The color of the subsoil is, in places, yellowish red, particularly where gravel is abundant. The parent material consists of the sandier materials of the glacial-drift deposits on the divides where excessive drainage prevails.

Occurrence.—The total area of this soil in Olmsted County is 2½ square miles. It occurs as small areas well distributed throughout the county, mostly in the northwestern part, particularly on or near the valley of South Branch Zumbro River, southeast of Oronoco.

Small patches of Thurston silt loam are mapped with this soil, the principal one being southwest of Haverhill. This land is undulating or smoothly rolling and is considerably more retentive of

moisture than is Thurston loam. The soil is dark-brown silt loam, to a depth of about 15 inches, underlain by brown or yellowish-brown heavy silt loam material, the texture of which becomes coarser and more sandy and gravelly to depths ranging from 24 to 30 inches. More crops may be grown on this soil than on typical Thurston loam.

General condition.—This land varies from gently to sharply rolling, with small knolls, knobs, and hillocks. On the tops of knolls and hillocks, the upper soil layer is more shallow and is lighter colored. Surface drainage is well established and underdrainage varies from good to excessive, the soils being very droughty.

Most of this land has been improved, and is included within fields of other soils better adapted to general farm crops. Gravel pits abound, this material being used for road and concrete construction. About 75 per cent of this soil is under cultivation, and most of the remainder is forested with oak, ash, elm, maple, birch, cottonwood, and wild plum.

Crops.—The principal crops are corn and rye, and barley, wheat, and oats are also grown. Clover grows fairly well except in dry seasons. Yields are good in moist seasons, but during summer droughts all crops suffer more quickly than those grown on soils having better moisture-retaining subsoils.

Suggestions.—Deep tillage, and the incorporation of organic matter in the form of manure and crop residues are methods recommended to increase the moisture-holding capacity of the soil and to supplement its supply of organic matter.

Mechanical analyses.—The following table shows the results of mechanical analyses of samples of the topsoil and subsoil of typical Thurston loam.

Mechanical analysis of Thurston loam

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
321364	Topsoil, 0 to 8 inches	2.2	4.7	5.4	22.2	12.2	42	11.3
321365	Subsoil, 8 to 20 inches	.6	3.5	4.9	26.2	13	36.4	15.3
321366	Subsoil, 20 to 36 inches	14.0	18.9	7.7	15.8	9.9	18	15.7

THURSTON LOAMY SAND

Description.—Thurston loamy sand consists of brown or dark-brown, loose, incoherent loamy sand from 8 to 12 inches deep, underlain, to a depth of 36 inches, by brown or yellowish-brown sand, also loose in structure and in some places containing stratified gravel. The substratum of sand and gravel continues to a considerable depth.

This soil closely resembles Sparta loamy sand. More thorough examination, however, shows that Thurston loamy sand has more gravel and coarse sand throughout the soil and is generally less uniform in texture. The positions occupied by the two soils are decidedly different. Thurston loamy sand is developed over sandy and gravelly drift materials which have been somewhat assorted by

glacial water and deposited on upland positions, but Sparta loamy sand has been deposited on valley terraces.

Occurrence.—The total area of this soil in Olmsted County is 3 square miles. It occurs principally in the township of Marion, near Bear Creek, from 4 to 8 miles southeast of Rochester.

General condition.—This land is undulating or rolling. Surface drainage is good, and underdrainage is rapid. The coarse texture of both soil and subsoil causes the soil to be very droughty.

Thurston loamy sand is unimportant agriculturally. Only about 40 per cent is cultivated, the remainder supporting a somewhat stunted forest growth, mainly of oaks.

Crops.—The principal crops are corn and rye. Corn is planted as early as possible in the spring, yields being fair when the rainfall is well distributed during the growing season. Rye matures early, before the summer drought. From 15 to 25 bushels of rye an acre and from 20 to 35 bushels of corn are normal yields.

Suggestions.—Droughtiness and lack of organic matter hinder production on Thurston loamy sand. Deeper tillage and the incorporation of large quantities of manure and crop residues will help correct these deficiencies.

BOONE FINE SANDY LOAM

Description.—To a depth of about 12 inches, Boone fine sandy loam consists of brown or grayish-brown fine sandy loam. Below this depth the material is yellowish brown, compact, and of fine sandy clay loam texture, slightly plastic when wet, and which continues to a depth of about 30 inches. Farther down the material is pale-yellow or yellowish-brown slightly compact, porous fine sand. This soil has developed from residual material originating from siliceous limestone and sandstone beds. It lies both above the bedrock and below bedrock outcrops, on colluvial slopes.

Occurrence.—The extent of this land in Olmstead County is 4.3 square miles, the largest areas occurring on low uplands in section 12 of Cascade Township and in sections 14 and 23 of New Haven Township. The remainder of the soil is well distributed over the county in close proximity to rough stony land, shallow-phase soils, and residual soils. In a few places it occurs as isolated mounds on areas of deeper soils. These soils are generally on colluvial slopes below outcropping parent bedrock. When sharing these slopes with Boone fine sand, Boone fine sandy loam usually occupies the lower position. This soil resembles the Thurston soils, except that the latter have topsoils more variable in texture and subsoils containing small quantities of coarse sand and gravel.

General condition.—This land ranges from gently to steeply sloping on colluvial slopes, and undulating to gently rolling in larger areas slightly dissected by drainage ways. The topsoil is very porous, and the subsoil is less so, although it also has poor water-holding capacity. Surface drainage is well established except on the steeper foot slopes where erosion is active.

Where Boone fine sandy loam adjoins cultivated soil, it is sometimes included in the crop field, but more often it is kept in cover crop of pasturage or hay grasses, or in the original forest. Erosion

and excessive droughtiness render the majority of these smaller tracts unfit for ordinary crop production, and as a rule only rye, buckwheat, and garden crops are planted. On the larger areas some cultivation is carried on and cropping to grains is practiced intermittently, but the land is used mostly for hay and pasture.

Crops.—Corn yields from 20 to 25 bushels an acre, oats and barley from 15 to 25 bushels each, rye from 15 to 20 bushels, and buckwheat from 8 to 15 bushels. Of tame hay grasses, timothy gives the best yields, averaging about 1 ton an acre. Clover and alfalfa give very uncertain returns because of their inability to withstand drought.

Suggestions and land values.—In the cultivation of the soil, manuring, plowing under of crop residues, and deep, thorough tillage are the methods used to improve the moisture-retaining capacity and to increase the quantity of organic matter. Where surface washing occurs, contour plowing may be practiced to retard erosion. On some areas of this soil, liming would be beneficial, as a slight or medium degree of acidity exists. No land values are available as the areas are so small that they are included in farms consisting largely of other soils. Farm values are decreased on account of inclusions of Boone fine sandy loam.

BOONE FINE SAND

Description.—Boone fine sand consists of brown or grayish-brown, loose fine sand, to a depth of about 12 inches, underlain by pale-yellow, somewhat compact fine sand. The soil is loose and very porous, low in organic matter, and has developed over siliceous limestone or sandstone.

Occurrence.—The total extent of Boone fine sand in the county is less than 2 square miles. It occurs as small bodies adjoining shallow-phase soils, rough stony slopes, or residual sandstone soils. The largest areas are in section 11 of Cascade Township and sections 14, 15, and 24 of New Haven Township. This soil occurs on positions over bedrock, reached at depths varying from 4 to 30 feet, or on colluvial slopes below bedrock outcrops, generally the latter. On colluvial slopes this soil usually lies above adjacent lower upland or terrace soils, and seldom adjoins first-bottom lands. Erosion is active on steeper unforested slopes, and the character of the soil is varied by each successive slope deposit of transported materials.

This soil occurs either over the level parent bedrock near the descending slopes upon which the rock crops out, or on small isolated tablelike remmants of the plain. On upper colluvial slopes it adjoins the Boone fine sandy loam of the lower slopes. The relative position of the two soils is shown by the areas mapped in sections 35 and 36 of Oronoco Township.

General condition.—On colluvial slopes the land ranges from gently sloping to steep. On larger tracts the surface is undulating and moderately sloping, little channeled by drainage ways. The isolated mounds are narrow crested and the buttes are bordered by steep descending slopes.

Subsurface drainage is excessive and crops on the soil are affected by drought in all seasons. Sometimes the rapid run-off causes damage from erosion, but ordinarily this does not take place on large areas.

Boone fine sand was originally forested, principally with oak and a considerable part of the sloping areas still retain their forest growth. The more gentle slopes are sometimes included in fields of adjacent soils and are thus brought under cultivation; otherwise little cropping is carried on except for small patches of rye, buckwheat, or graden crops.

Crops.—The larger areas are kept principally in timothy meadow, with occasional croppings to rye, corn, small grains, flax, or buckwheat. Clover stands usually are poor, and bluegrass furnishes pasturage only during seasons of high rainfall. Crop yields are about the same as or lower than on Boone fine sandy loam.

Suggestions.—Cultivation is not attempted on the more sloping areas nor is it advisable because of erosion and consequent droughtiness. The maintenance of a forest growth holds the soil in place best, but stands of timothy or ryegrass also would prove beneficial. When the ground is cultivated, liberal quantities of organic matter in the form of manure and crop residues incorporated in the soil, deep plowing, and preservation of a good mulch are necessary for maximum crop yields.

Land value.—No valuation of this land can well be made as it occurs in such small areas. It usually detracts from the value of farms on which it is located.

MUSCATINE SILT LOAM

Description.—Muscatine silt loam consists of brown or nearly black, smooth, friable silt loam, ranging from 10 to 14 inches deep, underlain by mottled gray and yellow silty clay loam, moderately friable, to a depth of 18 or 20 inches. Below this occurs grayish-brown or yellowish-gray silt loam material, conspicuously mottled with yellow, orange, and rust-brown, and more friable than the soil above. This continues to a depth of about 36 inches, and is underlain by drift material which in most places is mottled yellow and gray in color, sandy or gravelly clay loam in texture, and more plastic when wet and more compact than the soil above.

This is an upland soil developed over loess, as are soils of the Tama series which it resembles but from which it differs in having a mottled subsoil. This mottling is caused by poor drainage. This explains why this soil has developed on flat or smoothly undulating areas.

Occurrence.—Only a few small bodies are mapped, and these are in the southern part of the county, south of Pleasant Grove.

General condition.—This land is smoothly undulating or nearly flat. Except on flatter areas the surface run-off is adequate, but underdrainage is poor on all areas. Because of this, the soil is sufficiently cold and wet to delay spring plowing and planting and to hinder the proper growth of deep-rooted crops. However, Muscatine silt loam contains ample organic matter and retains moisture well.

About 75 per cent of this land is cultivated, the rest remaining in native prairie pasture. It is used with fair success for general farm crops, such as corn, small grains, hay, and pasturage. It is not adapted to tree fruits, nor do potatoes yield as well as on better-drained soils. It is particularly good pasture soil, alsike clover being used with better results than red clover.

Land value.—The value of this land ranges from $40 to $80 an acre, depending on improvements and the distance from transportation lines and markets.

Suggestions.—Muscatine silt loam is benefited by tile drainage and moderate applications of lime. This would increase the productiveness of the land, adapt it to a wider diversification of crops, and allow a better crop rotation.

DODGEVILLE SILT LOAM

Description.—To an average depth of 15 inches, Dodgeville silt loam is dark-brown or black mellow silt loam containing considerable organic matter. Below this is yellowish-brown, moderately friable clay, plastic when wet, this plasticity increasing with depth until bedrock is reached at depths ranging from 4 to 5 feet. The soil is developed over limestone with a thin layer of drift or loess materials on the surface.

Occurrence.—Nearly 9 square miles in Olmstead County is covered by Dodgeville silt loam, nearly half this land is in Haverhill Township. The largest areas occur on elevated uplands in Marion and Haverhill Townships. Small tracts occur elsewhere on glacial outwash terraces or on colluvial slopes. The subsoil of these terrace and slope areas is usually less plastic, and the topsoil is deeper than is the typical soil. In places it closely resembles Buckner silt loam which it borders on slope positions, and Waukesha silt loam which it adjoins on high terrace positions.

In some areas the subsoil is sandy clay underlain by siliceous limestone, and in others it is clay underlain by argillaceous limestone. The siliceous parent rock weathers to a thin vein of loose sand below the heavier subsoil. Generally the more friable, less plastic subsoils developed over coarser-grained limestone occur on high, thinly covered terraces and colluvial slopes; whereas the heavier, more plastic subsoils developed over fine-grained limestone occur on uplands.

In some places the soil is shallow, and the bedrock is within 2 feet of the surface. Such bodies occur on slopes below deeper soils or on the edge of a residual terrace, as in section 22 of New Haven Township. There is less than 1 square mile of this shallow soil. In some places these sloping shallow bodies have a lighter-colored topsoil, as in section 21 of Haverhill Township. This lighter-colored topsoil also occurs in a few places on upland positions where Dodgeville silt loam borders Clinton or Lindley soils, as in section 30 of Haverhill Township. In section 26 of Oronoco Township similar light-colored topsoils occur on terrace and colluvial slope positions grading from the more elevated Clinton soils.

General condition.—This land varies from steep on slopes to undulating on upland positions and almost level on high terrace positions. Most of it is nearly level or undulating, and is only slightly dissected by drainage ways, except along a few main stream courses.

Drainage is well established. Although surface drainage is somewhat sluggish, the ready drainage through the subsoil to deep dissected drainage ways or to lands of lower level, prevents saturation. The lack of tributary drainage ways is counteracted by an active underground movement to seepage slope outlets above the stratum

of bedrock. Occasionally in dry spells the shallow soil is unable to retain sufficient moisture for crop needs. However, droughtiness is seldom a drawback on this soil.

Practically all of this land is cultivated except the steeper slopes and shallower areas which are kept in permanent pasture or forest. Under cultivation grain cropping is not practiced so continuously as it is on deeper soils.

Crops.—Corn is the main crop, and oats, clover and timothy, barley, rye, and flax are also grown. Corn yields from 40 to 45 bushels an acre; oats, from 30 to 35 bushels; barley, from 25 to 30 bushels; rye and wheat, from 15 to 20 bushels each; clover and timothy hay, 2¼ tons; clover, 2 tons; and flax, from 10 to 12 bushels.

Livestock.—Because of less continuous grain cropping on this soil, a comparatively large percentage is kept in hay meadow and pastures. As a result of this practice, cattle grazing is given more attention than hog raising. However, the number of livestock kept on farms on this land does not equal the number kept on farms of the Tama and Carrington soils.

Land value.—Farms are well supplied with buildings. Farms with average building improvements and which are reasonably close to local markets ranged in value from $100 to $150 an acre during 1923.

Suggestions.—A more systematic practice of crop rotation, and more liberal manuring is recommended for the improvement of this soil, as it may easily be kept in good tilth with thorough cultivation. On shallower areas of the soil, methods to increase the moisture-holding capacity are recommended, such as deeper, more thorough plowing, and the incorporation of more organic matter in the form of manure and crop residues.

DODGEVILLE LOAM

Description.—The topsoil of Dodgeville loam is dark-brown or black loam containing moderate quantities of organic matter to a depth of about 15 inches. Below this the material is brown well-oxidized friable silt loam or clay loam to a depth of about 30 inches, where it is underlain by yellowish-brown compact silty clay, or clay which is very plastic when wet. At a depth varying from 3 to 6 feet is the bedded limestone over which the subsoil has developed.

The soil occurs where the limestone bedrock is not deeply covered with drift or loess. The soil-forming processes have acted not only upon the soils but also upon part of the bedrock. The parent limestone, whether argillaceous or siliceous, has contributed to the composition of the lower part of the soil. The subsoil over argillaceous limestone is very plastic compact silty clay, while over coarser-grained siliceous limestone it is clay loam in texture, and a thin layer of loose, porous sand derived from disintegrated sandstone lies immediately over the parent rock. On most areas there is a concentration of fine particles deposited by percolating waters which are retarded by the impervious bedrock below. This is more common, however, in soils developed over argillaceous limestone than in those developed over siliceous limestone. In general, Dodgeville loam has less concentration and less compaction of clay particles in the subsoil

than has Dodgeville silt loam. The area in section 23 of Eyota Township is typical of soil developed over argillaceous limestone, and the one in section 6 of Haverhill Township is characteristic of soil developed over siliceous limestone.

The Dodgeville loam in section 6 of Haverhill Township is representative of the soil which occurs on the thinly covered glacial outwash terraces which are underlain by bedrock. In many places the residual soil of these outwash terraces does not contain compact, plastic material except in thin layers in the lower part of the subsoil; the material in the upper part varies in texture from heavy fine sandy loam to sandy clay loam. In such positions Dodgeville loam adjoins Waukesha and O'Neill terrace soils, differing from them particularly in the depth to the more plastic, finer, and more texturally uniform layer that rests upon the parent rock.

On colluvial slopes Dodgeville loam is differentiated from the deeper soil material of adjoining Buckner soils by its position. A variation of Dodgeville loam resembling Buckner soil occurs in the south half of section 12 of Cascade Township, others being found in sections 5 and 32 of Haverhill Township, section 2 of Oronoco Township, and section 11 of Cascade Township. These subsoils are friable, yellow-brown sandy clay loam throughout, slightly plastic when wet.

On eroded slopes and on extremely thinly covered flats the soil averages but 2 feet in depth, and the rock crops out in places. Variations of this kind occur in sections 21 and 30 of Eyota Township and in section 5 of Marion Township. In some areas, organic matter is lacking in the topsoil because the original forest growth prevented all but a sparse growth of indigenous prairie grasses. In such areas the topsoil is lighter colored than typical. Variations of this kind occur in section 3 of Kalmar Township and in section 33 of Rochester Township.

General condition.—As this soil rests upon a horizontal bedrock substratum, areas are level or undulating and are dissected by main drainage ways. In some places the soil rests upon a small bedrock remnant elevated above the surrounding deeper soils and forms ridges, whereas on colluvial slopes the land ranges from gently sloping to steep.

Surface drainage is fairly good because of the proximity of main drainage ways. Subsurface drainage is well established but is arrested by the underlying bedrock. The water, however, finds an outlet through underground channels to seepage slopes, which sometimes makes the soil droughty during very dry periods.

Of the 8.7 square miles of Dodgeville loam in Olmsted County, only a small percentage (on slopes) remains in native grass pasture or in forest, as the larger percentage is cultivated. Cropping systems and management of the soil are similar to those described for Dodgeville silt loam; yields of rye are as high, but yields of other crops average less.

Livestock.—Farms on this soil are fairly well stocked. Cattle grazing is of more importance than it is on the Tama and Carrington soils, and hog raising is less important. The number of cattle and hogs is about equal on the average farm.

Land value.—Values for this land ordinarily average a little lower than for Dodgeville silt loam.

Suggestions.—More liberal applications of manure and the turning under of crop residues are recommended as means of maintaining the fertility of the soil and of increasing its moisture-holding capacity. Crop rotations also would prove beneficial.

BUCKNER SILT LOAM

Buckner silt loam to a depth of about 20 inches is dark-brown or black silt loam underlain by lighter-colored mellow material, which becomes slightly more compact with depth. Small quantities of sand particles occur throughout the soil.

This soil has developed principally from material which has been washed down from moderately steep upland slopes, and which varies according to the upland soils which contribute this material. Areas of Buckner silt loam usually border more uniform silty drift and loess soils. In a few places the parent material is a stream deposit.

Occurrence.—The total extent of Buckner silt loam in Olmsted County is 10.5 square miles, and it occurs in patches throughout the county. In section 26 of High Forest Township colluvial areas usually occur on three separate positions—at the foot of main valley bluffs and overlying terraces, at the foot of upland drainage-way slopes and above their narrow bottom soils, and on both slopes and basins of upland drainage ways which have not as yet developed any flood plains. The latter in a few places extend to shallow dissected drainage-way basins in terraces, as in section 17 of Haverhill Township. Generally in such places the soil lies higher above the stream than bottom soils, and nearer the stream than areas of Clyde or Bremer soils.

Where adjoining upland soils are light colored areas of Buckner silt loam have lighter-colored topsoils, as in sections 12 and 24 of Pleasant Grove Township. Where bordered by loam and sandy loam uplands or terraces these colluvial drainage-way deposits are lighter in texture, and in some places the material is loam to a depth of 3 or 4 feet, as in section 9 of Marion Township.

General condition.—Areas of Buckner silt loam vary in the degree of slope, but are rarely too steep for cultivation. In the few places where the soil occurs on typical terrace positions the surface is almost level, and is undissected by drainage ways.

Internal drainage is well established, but on steeper slopes the surface run-off causes some erosion.

Buckner silt loam is recognized as a very productive soil, but it is usually farmed with other soils. The upland slopes of adjoining soils are generally not cultivable on account of their steepness or of the shallowness of the soil, and are used for pasture in conjunction with Buckner silt loam. In some places the slopes of Buckner silt loam have not been cleared of the original forest growth. Only a few of the broader stretches of the soil are cultivated.

Crops.—When the ground is cultivated, excellent yields of all crops usually are obtained. The acreage in grain crops exceeds that in hay. Corn yields about 45 bushels an acre; oats and barley, from

25 to 30 bushels each; rye and wheat, 20 bushels each; and flax, 10 bushels. The tame hay grasses yield exceedingly well and clover and alfalfa stands usually are good. Timothy and clover yields from 2 to 2½ tons an acre; clover alone, from 2¼ to 2½ tons; timothy alone, from 1½ to 2 tons; and alfalfa, 2½ tons. When ground is seeded to hay, clover either alone or with timothy is most commonly grown, though some small areas are in alfalfa. Most of this land is kept in permanent bluegrass pasture, which remains green practically throughout the season.

The soil can be plowed under wide ranges of moisture conditions. On some of the slopes contour plowing is practiced to retard erosion. Little manure is applied to the soil, but larger applications should prove beneficial.

CLYDE SILTY CLAY LOAM

Description.—Clyde silty clay loam, to a depth of about 6 inches, is black, moderately friable, silty clay loam high in organic matter. This is underlain by black clay, which contains almost as much organic matter as the layer above but which is less friable and very plastic when wet. Below this the material is dark grayish-brown or gray plastic clay, with rust-brown and yellow mottlings. Sand and gravel are present throughout the soil, the quantity increasing with depth and there are many bowlders on the surface.

Clyde silty clay loam has developed from finer-textured drift materials deposited by ice and weathered in position on areas where drainage is poor. The decay of the rank prairie and slough grasses of these tracts and the subsequent incorporation of this organic matter have made this soil black, and poor drainage has caused the mottled appearance of the poorly oxidized subsoil.

Occurrence.—About 20 square miles of this soil occur in Olmsted County. The areas are well distributed but usually adjoin soils of the drift plain. Most of this soil lies on headwater upland drainage basins or on wider, more deeply dissected depressions below headwaters. The largest tracts are in High Forest and Rock Dell Townships, in association with Carrington silt loam of the gently rolling uplands. In Rock Dell Township this soil is associated with areas of muck and in some places it is covered with a layer of muck from 2 to 6 inches thick. In some places the topsoil is clay loam, as in section 35 of New Haven Township.

General condition.—This soil occurs as flat depressed areas and usually extends up the adjoining gentle slopes. Drainage is poor and the soil is excessively moist except during the drier parts of the year. Some areas are almost permanently saturated.

Most of this soil is kept in pasture or in wild hay meadow. Grass growth is abundant and on the more poorly drained areas takes the form of a hummocky stand rather than a smooth sod. Drainage is necessary before this soil can be cultivated, but this has not been considered practical. This land furnishes excellent pasturage and usually the acreage on any one farm is not too large to be retained as pasture land.

Valuation of the soil is difficult because the areas are small and scattered.

CLYDE SILT LOAM

Description.—To a depth of about 12 inches, Clyde silt loam is black silt loam high in organic matter. Below this, to a depth of about 24 inches, occurs dark grayish-brown or black silty clay loam material, which is plastic when wet and but little lower in organic matter than the topsoil. The lower part of the subsoil is dark grayish-brown silty clay, with gray mottling, which is plastic when wet and heavier than the soil above.

This soil has developed from finer and more uniformly textured drift deposits laid down in depressed positions on flat terraces and weathered under poor drainage conditions. The incorporation of organic matter from the rank growth of prairie and slough grasses has affected the soil material to a depth of 20 or more inches. Sand and gravel are present in both soil and subsoil, and there are bowlders on the surface.

Occurrence.—There are 3.6 square miles of Clyde silt loam in Olmsted County. It is generally closely associated with Clyde silty clay loam, either on slopes above depressions of the heavier soil or on the better-drained parts of the depression. Clyde silt loam is usually intermediate in position between Clyde silty clay loam and the more elevated silt loam soils of the Carrington and the Tama series. Depressions in which the soil is all Clyde silt loam are few in number, and they are but little better drained than those in which Clyde silty clay loam occurs. In a few cases this soil occurs on terraces, as in the extreme southwestern section of the county. Here the black surface soil, at a depth of 15 inches, is underlain by dark-colored, distinctly mottled, plastic material, below which, at a depth of about 30 inches, is a loose, sandy, and gravelly substratum.

Clyde silt loam is associated principally with Carrington silt loam. In most respects it resembles the Bremer soils, occurring in like positions on the loess areas, but it differs from them in having drift sand and gravel in the soil, and in being less uniform in texture.

General description.—Areas of this land are depressed or very gently sloping. Drainage is poor but not so poor as that on Clyde silty clay loam. With tiling, the drainage of most areas can be improved so that moisture conditions become favorable for cropping.

Very little of this land is cultivated; most of it is in hay and pasture. Tame hay grasses are gradually superseding slough grasses.

Crops.—This land which is cultivated is heavily and continuously cropped. Except in very wet seasons, yields of corn and hay are excellent. Small grains do not produce well even in a normal season, and failures from lodging occur frequently. The cropping methods and soil improvement practices on Muscatine silt loam are followed on this soil.

Land values.—No land values for Clyde silt loam can be given, as areas of this soil are in most cases too small to be a factor in determing the value of the farms on which they occur.

WAUKESHA SILT LOAM

Description.—Waukesha silt loam consists of dark-brown or black, mellow silt loam, about 20 inches deep, underlain by brown or yel-

lowish-brown, friable silty clay loam material which is moderately plastic when wet. Small quantities of sand and gravel are present.

This soil has developed from the finer-textured materials of glacial outwash deposits on terrace which possibly had deposited on them some loess. Originally there was a good growth of prairie grass on this land, and this gives the soil its present dark color and its large supply of organic matter.

Occurrence.—The acreage of Waukesha silt loam in Olmsted County is equivalent to about 16 square miles, and it represents nearly one third of the terrace land. This soil occurs adjacent to all main drainage courses of the county. The largest bodies are in Dover, Salem, and New Haven Townships. The soil along South Branch Whitewater River in Dover Township occurs on gently sloping valley-filling positions, slightly modified by foot slope colluvial deposits. Here the topsoil is depeer and the subsoil is looser in texture than typical, and the soil resembles Buckner silt loam in some respects. Another variation similar to this is in New Haven Township.

The terrace development of the soil in Salem Township is typical except for small areas where the gravelly subsoil resembles that of the O'Neill soils. Where on terraces with other soils, Waukesha silt loam generally occurs in a position slightly above the Bremer soils and below all other terrace soils. Where it adjoins lighter-colored terrace and upland soils it is lighter colored than typical, as in sections 35 and 36 of Rock Dell Township. This lighter-colored topsoil is a result of the original growth of forest on such areas.

General condition.—The terraces on which Waukesha silt loam occurs range from 5 to 50 feet above the bottom lands. The land varies from almost level to gently sloping and is but slightly dissected by drainage ways. Drainage on this soil is well established, and moisture conditions are favorable. Most of this soil is cultivable.

Crops.—This soil is rather heavily cropped, corn and oats being the main grain crops grown, and timothy and clover hay ranking third in importance. All crops yield well, averaging about the same as those on the Tama and Carrington upland soils. The cropping systems and methods of cultivation are the same as those described for Tama and Carrington soils, and land values are about equal.

WAUKESHA LOAM

Description.—Waukesha loam consists of dark-brown or black mellow loam, about 18 inches deep, underlain by brown or yellowish-brown heavy loam or clay loam material which usually contains some sand and gravel. In some places below a depth of 4 feet there is a thin stratum of loose sand and gravel similar to that present in the O'Neill soils. The topsoil is seldom plastic when wet but the subsoil is usually moderately plastic under moist conditions. This soil has developed from glacial outwash terrace deposits of finer-textured materials.

Occurrence.—A total area of about 3 square miles is covered by Waukesha loam in Olmsted County. The areas are small and widely distributed throughout the county. Where associated with other

soils on the larger terraces Waukesha loam generally occurs on positions slightly above silt loams and below all other soils. Where the soil is adjacent to uplands and has been modified by wash, the topsoil is deeper and the subsoil is less developed. Where this material has been washed from light-colored uplands, the topsoil is lighter colored than typical, as in section 2 of Oronoco Township. The same is true where the soil occurs on gentle slopes which are slightly above adjacent bottoms, such as the areas mapped in sections 8 and 9 of Rochester Township.

General condition.—Waukesha loam occurs on almost level or gently sloping terraces from 10 to 50 feet above the bottom lands, and is rarely dissected by drainage ways. Drainage assures ideal moisture conditions in normal seasons.

The use of this soil depends on adjoining soils, as the areas are small. Some of the land is forested, principally with oak, poplar, maple, ash, and elm.

A little more than half of the remainder is cropped to grains, one-fourth to tame hay, and the rest is in pasture. Yields of all crops grown are good, but are ordinarily a little lower than on the silt loam member of the series. Cropping practices and methods of cultivation are practically the same as those for Waukesha silt loam. However, Waukesha loam can be worked under a slightly wider range of moisture conditions than can the silt loam.

BREMER SILT LOAM

Description.—Bremer silt loam consists of black silt loam, about 15 inches deep, underlain by dark-gray or grayish-brown material, slightly mottled with rust brown and gray, which ranges in texture from silty clay loam to silty clay. The topsoil is rich in organic matter and is moderately friable under average moisture conditions. The subsoil is plastic when wet, somewhat compact when dry, and ordinarily a little too retentive of moisture. The soil in most places is free from bowlders and contains little sand and gravel. When present, these coarser materials occur only at a depth of 2 or more feet. Bremer silt loam differs from Clyde silt loam in its freedom from coarse materials on the surface and within 2 feet of it. In other respects these two soils are very similar.

Occurrence.—Bremer silt loam covers a total area of about 5 square miles, widely distributed throughout the county. It usually occurs in depressions on uplands within areas of loess or silty drift soils. It has developed from sediments of a silty nature which was deposited over glacial drift, and the material has been partly assorted by the action of the waters which formely filled these depressions. Weathering has taken place under poor drainage conditions and the subsoil is poorly oxidized. A deep black topsoil has resulted from the incorporation of organic matter from the decay of the native grasses which were so abundant on this soil. In some places the accumulation of organic matter has been so rapid that a layer of muck from 2 to 6 inches deep has formed on the surface. Such areas are in sections 29 and 33 of Cascade Township and elsewhere. In the broader and more depressed areas, the texture of the topsoil grades downward into heavier clay loam or silty clay loam.

Where Bremer silt loam occurs on smaller upland drainage way depressions it lies above the Wabash soils and below associated areas of Clyde or Buckner soils. The tract in section 8 of Rochester Township in association with Buckner and Wabash soils has a subsoil less plastic and lighter in texture than the typical, resembling that of Wabash soil in character.

The largest areas of this soil occur at the headwaters of Cascade Creek in Salem Township, and on a broad tributary depression in Cascade Township. Some Bremer silt loam occurs in depressions on terraces, as in sections 8, 12, and 23 of Rochester Township, where the soil lies at a higher elevation than the adjoining Waukesha and O'Neill soils.

General condition.—Areas of this land vary from flat to very gently sloping. Natural drainage is sluggish and water frequently remains on the surface for several days after rains. However, the soil is seldom permanently saturated, and some areas are drained sufficiently for fairly certain cropping in normal seasons. On a few tracts artificial drainage has been established, but most areas are too small to justify such means of improvement.

A few of the better-drained areas are cultivated, but the land is utilized chiefly for wild or tame hay pastures. A heavy growth of bluegrass affords execellent pasturage. When it is cultivated, the soil seems better adapted to corn than to small grains, as the latter grow rank and are late in maturing, often causing light grain production and loss from lodging. Early maturing strains of staple crops are considered better for this soil. During periods of excessive moisture, conditions are unfavorable for plowing or cultivation of the soil. Clean cultivation is, therefore, more difficult than on better-drained upland soils. When dry, the topsoil tends to crack. Cultivation can be carried on under a little wider range of moisture conditions than on Bremer silty clay loam.

Land values.—Land values on Bremer silt loam are difficult to determine, because the bodies are so small that they are usually included in farms composed mainly of other types of soil. In 1923 values ranged from $30 to $85 an acre, and were sometimes higher for cultivable areas.

Suggestions.—Drainage is the greatest need of this soil, but such improvement is justified only on farms on which occur large tracts of this land.

BREMER SILTY CLAY LOAM

Description.—Bremer silty clay loam consists of black, moderately plastic, silty clay loam or silty clay, to a depth of about 15 inches, underlain by gray or dark grayish-brown, plastic silty clay or clay mottled with rust-brown, yellow, and gray. The topsoil is rich in organic matter. The subsoil, below a depth of about 24 inches, frequently contains small quantities of coarse sand and gravel, but the soil above is comparatively free from these particles.

Bremer silty clay loam is developed from sediments washed down from loessial or silty drift soils and deposited in poorly drained depressions. In some places some assortment of materials has been made by inflowing water. A few areas have been subject to long periods of swampiness, and this accretion and assortment of ma-

terials is still taking place. This soil originally supported dense growths of wild prairie and slough grasses which, through decay and subsequent incorporation of carbonaceous residue, have imparted to the soils their deep-black color. In some areas the accretion of this decayed organic matter has been rapid and in advance of the processes of incorporation in the soil, so that an unconsolidated surface layer of muck, varying from 2 to 8 inches in depth, has accumulated, as in sections 7 and 9 of Salem Township.

Occurrence.—Bremer silty clay loam, as mapped, occurs only on depressions in association with upland soils. The total acreage of this soil in Olmsted County equals about 3 square miles. More than two-thirds is in Salem and Pleasant Grove Townships; the remainder occurs as small bodies throughout the county. In some upland drainage-way basins this soil is surrounded by Tama soils, as in sections 15 and 16 of High Forest Township. A large area occurs in section 33 of Pleasant Grove Township, in association with Muscatine silt loam. The large bodies in sections 7 and 9 of Salem Township occur in a wide depression below Carrington silt loam.

General condition.—This soil occurs in flat or very gently sloping depressions, and drainage is sluggish and poorly developed. A few areas are almost permanently saturated and in a water-logged condition, but most of the soil is favorable for cultivation during the drier seasons. Drainage improvements are necessary. A very small percentage of this soil has been improved in this way, and cropping, principally to corn, is practiced. Small grains do not produce so well on this soil, because of the loss from lodging. On account of the excessive moisture-holding capacity of the soil, spring plantings usually are later than on the better-drained soils. The earlier yields of staple crops are greater than of those maturing later.

This soil can not be plowed or cultivated under a very wide range of moisture conditions. When worked too wet, the formation of clods results; and when dry, the surface tends to bake and crack. Practically all the Bremer silty clay loam is in pasture and hay lands. Pasture grasses flourish and remain green throughout the season, and the yield of hay is good. Cultivation of this soil is considered impracticable, unless a farm lacks cultivable land of other soils and the area of Bremer silty clay loam is large enough to justify the necessary drainage improvements.

O'NEILL LOAM

Description.—The topsoil of O'Neill loam is dark-brown mellow loam to a depth of about 15 inches. Below this, to a depth of about 40 inches, the subsoil is yellowish-brown fine sandy loam or sandy loam material which contains some gravel. The quantity of gravel increases downward to a depth of 4 or 5 feet, below which are loose, porous, sandy gravel beds of varying thickness. The topsoil contains some organic matter and is retentive of moisture; but as the subsoil is deficient in organic matter and is loose and porous, subsurface drainage is excessive during periods of low rainfall.

Occurrence.—The total extent of O'Neill loam in Olmsted County is more than 4 square miles, and this soil is widely distributed as small bodies. It occurs on terraces in glacial outwash plains. These

terraces range in height from 20 to 50 feet above the bottoms and lie from 75 to 150 feet below the uplands. This soil usually occurs at elevations higher than Waukesha soils, and slightly below lighter-textured sandy loams and loamy sand. The largest area covers less than 1 square mile.

A few variations from the typical soil described are mapped as O'Neill loam. Where this soil adjoins residual upland areas, in many places it is underlain by a lower stratum of bedrock upon which the valley-filling deposit is shallower than usual, but in no place is it shallower than 4 feet. Such bodies lie in sections 17 and 31 of Haverhill Township. The soil, however, does not possess the characteristics of residual soils but of those developed from residual and drift materials transported and deposited upon these underlying rock strata.

In many places there is a subsurface layer of heavier-textured silt loam or clay loam which results in soil more retentive of moisture than typical. In some places the subsoil contains more clay and silt which serve to cement the sand into a moderately plastic body when wet, and thus result in greater water-holding capacity. In section 24 of High Forest Township the topsoil is as heavy as silt loam. In other places the soil is lighter-colored loam, similar in color to the soils of the Sparta series, as in section 26 of Cascade Township.

General condition.—This soil occurs on level or very gently sloping terraces slightly dissected by drainage ways issuing from the uplands. Subsurface drainage is excessive, and during periods of low rainfall crops may suffer. In normal seasons the soil moisture is sufficient to support crops.

Originally a good growth of prairie grasses covered most of this land, but there was also forest growth, principally oak. These forested areas still remain in a few localities, and there is also a sparse covering of bluegrass. About one half of this land is cultivated and cropped to corn and small grains, and the remainder is kept in hay and pasture.

Crops.—Corn, barley, oats, and rye are grown with satisfactory yields except in years of low rainfall. Timothy and clover is the tame-hay crop commonly grown. Clover suffers more than timothy from lack of moisture and its yields are therefore more uncertain. O'Neill loam has the advantage of being moderately well supplied with organic matter. Also it may be plowed under a wide range of moisture conditions. The principal difficulty is the porosity of the subsoil and the resultant droughtiness during drier seasons. However, with good tillage a surface mulch can be maintained which will retain sufficient moisture in normal seasons. Manure is used on grain and clover land, but a more liberal use of it is recommended.

O'NEILL SANDY LOAM

Description.—O'Neill sandy loam consists of dark-brown sandy loam, about 15 inches deep, underlain by yellowish-brown loamy sand containing small quantities of gravel and pebbles. The topsoil is moderately retentive of moisture, but the subsoil is very porous. This soil has developed from the sandier materials of the deposits

formed by glacial waters and which now occur on terraces high above overflow from the streams which now flow through the valleys.

Occurrence.—The total acreage of O'Neil sandy loam in Olmsted County is equal to about 4½ square miles. The largest area lies in Marion Township, where the terraces are from 25 to 50 feet above the bottoms and from 75 to 125 feet below the adjacent uplands. The uplands which border these terraces are predominantly sand.

Other areas are in Cascade Township adjacent to South Branch Zumbro River valley. In section 13 of this township is an area of this soil associated with Dodgeville loam, and the soil here is from 5 to 10 feet deep, overlying the bedrock. A similar substratum is probably present in a few other localities. In section 24 a part of the area has a subsoil varying in texture from sandy loam to loam, heavier and less porous than typical. Other bodies are small. This soil generally occurs in position slightly above heavier-textured loams and silt loams of other terrace soils, and slightly below Sparta loamy sand and Sparta sandy loam.

General condition.—This land is nearly level except for the dissection of minor tributary drainage ways from the uplands, or the small colluvial deposits adjacent to bordering uplands.

Drainage is excessive because of the porous substratum, and crops suffer from lack of moisture even under normal seasonal conditions.

On this land there was originally a moderate growth of prairie grasses and some sparse forest growth, mainly scrub oak. At present small areas are in wooded pasture land. Bluegrass furnishes good pasturage except during the drier periods.

Crops.—Corn, small grains, chiefly rye and timothy hay, are the principal crops grown. As it is difficult to obtain clover stands this crop is seldom grown. Yields of various crops are about the same as those on the upland Thurston soils, and the cropping system and manner of cultivating the soil are also similar.

Land values.—The 1923 market value of this land ranged from $50 to $80 an acre, depending on improvements and nearness to markets.

SPARTA LOAMY SAND

Description.—Sparta loamy sand consists of brown or dark-brown loamy sand, about 12 inches deep, underlain by pale-yellow or light grayish-brown sand, loose and porous, which contains some gravel. In some places there is a gravelly stratum at depths ranging from 4 to 5 feet. The amount of organic matter in the soil is small.

The parent material was deposited from glacial waters with some modification by more recent streams or by slope wash. In all probability the material was transported for short distances only, and the sandy uplands on which the Sparta terrace soils occur contributed the greater part of it.

Occurrence.—Sparta loamy sand covers about 3 square miles in Olmsted County, usually adjoining sandy residual and drift upland soils. The largest areas of this soil are on terraces along Bear Creek and Badger Run in Marion Township. These terraces are from 25 to 50 feet above the first bottoms and from 75 to 100 feet below the uplands. Where the land borders O'Neill and Waukesha soils, it

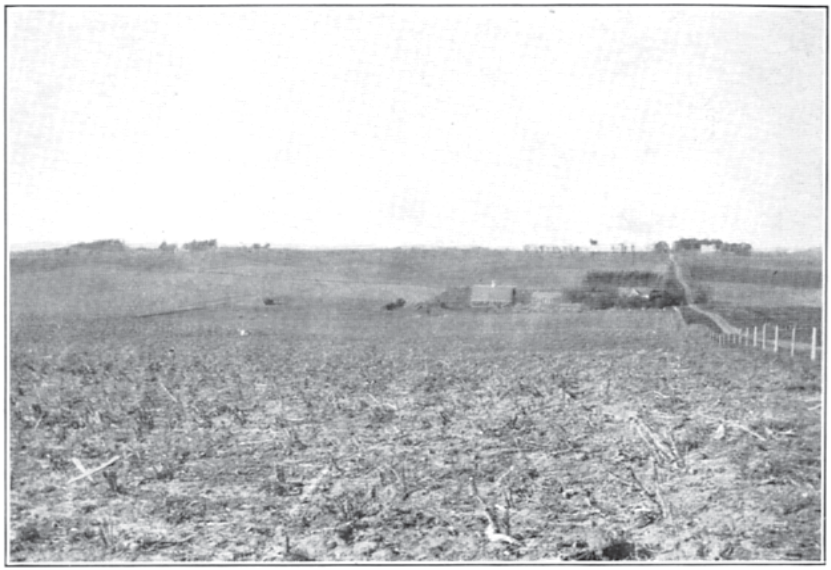

FIG. 1.—SURFACE FEATURES AND FARMS ON AN AREA OF TAMA SILT LOAM

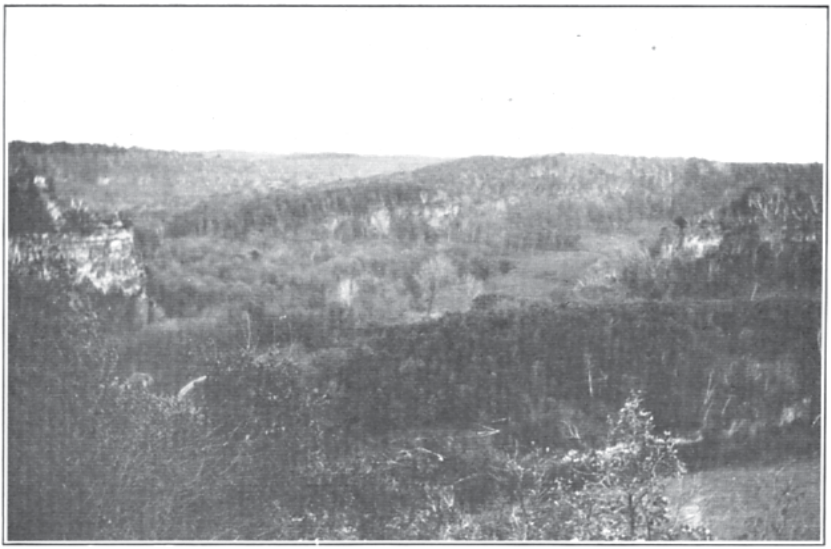

FIG. 2.—WHITEWATER CANYON IN THE NORTHEASTERN PART OF OLMSTED COUNTY. THIS SHOWS TYPICAL WOODED ERODED COUNTRY ALONG THE VALLEYS OF THE LARGER STREAMS

lies on ridges or elevations slightly above those soils, as in section 14 of Cascade Township. In some places the subsoil is more gravelly than typical. In section 11 of Cascade Township the soil occurs on a narrow terrace gently sloping from Boone residual soils which lie in position from 30 to 50 feet above.

General condition.—This soil occurs on level terraces of moderate elevation, somewhat dissected by drainage ways. Drainage is excessive and causes crop failures during periods of low rainfall.

Originally there was a scant growth, mostly of oak on this land, and it still grows on perhaps one-third or one-half of the land. Pasture grasses die down during the driest periods of the grazing season.

Crops.—Timothy hay grows well, averaging about 1¼ tons an acre. Clover is seldom seeded, because it is difficult to keep a good stand during dry periods. Small grain yields, of which that of rye is the largest, range from 15 to 20 bushels an acre. Corn yields range from 20 to 40 bushel an acre, depending on the seasonal moisture supply, and buckwheat yields from 15 to 20 bushels. Some potatoes and other garden crops for local markets are grown on this soil.

Sparta loamy sand may be worked under a wide range of moisture conditions. Under the most successful cropping practices moisture is retained in the soil through deep mulching and the addition of organic matter in the form of manure and crop residues. Little liming is now practiced, but it is probable that applications of lime would be beneficial.

Land values.—The value of this land in 1923 ranged from $35 to $50 an acre. The buildings and other improvements on the farms are fairly good.

SPARTA SANDY LOAM

Description.—Sparta sandy loam consists of brown or dark-brown sandy loam, to a depth of about 12 inches, underlain by yellow or pale yellowish-brown loamy sand, loose and porous in structure. Small quantities of coarse sand and gravel are present in the topsoil and subsoil. The subsoil, in a few places, contains faintly stratified sand and gravel, but these occurrences are generally more than 4 feet below the surface. The soil has developed over sandstone, transported and redeposited by glacial waters. The topsoil has moderate water-holding capacity, but the subsoil is very porous. Even in seasons of normal rainfall, crop yields are reduced to some extent by drought. This soil closely resembles O'Neill sandy loam except that it has a shallower lighter-colored topsoil.

Occurrence.—Sparta sandy loam covers less than 2 square miles in Olmsted County, and the areas are all small. This soil occurs on low terrace or valley-filling positions which range from 15 to 100 feet above the adjacent bottom lands. The bordering uplands are usually steep and the terrace soil receives slight modifications of slope wash. The higher terraces are bordered by gently sloping uplands, as a rule, and colluvial material is not so frequently a surface modification. Where Sparta sandy loam adjoins other terrace soils, it generally occurs in positions above Waukesha soils and on a level with O'Neill soils. In section 32 of Haverhill Township the texture of

the topsoil is fine sandy loam. In some other places the topsoil is lighter fine sand or loamy sand, as in section 14 of Cascade Township.

General condition and crops.—On some of the land there is a forest growth, mainly of oak and poplar. A very small percentage of this soil is cropped to grains. The production of grain usually is reduced during long dry periods. Timothy hay, corn, and rye are the principal crops grown. It is difficult to procure good stands of clover. Liberal applications of manure are necessary to insure the best returns. Truck farming is carried on to some extent in the vicinity of Rochester.

Land value.—The market value of this land is hard to estimate because it occurs in such small areas. During 1923, farms including this soil with other soils of about the same value located reasonably close to local markets were valued between $50 and $75 an acre.

Suggestions.—Suggestions for the improvement of this soil are liberal manuring, deeper plowing, and maintaining a good surface mulch to conserve the soil moisture.

SOGN SILT LOAM, POORLY DRAINED PHASE

Description.—To a depth of about 8 inches, poorly drained Sogn silt loam consists of nearly black, heavy silt loam, rich in organic matter and moderately plastic when wet. Between depths of 8 and 18 inches, the material is black silty clay, underlain by plastic clay with pale-yellow and greenish mottlings. The parent material of shaly limestone occurs at depths varying from 4 to 5 feet.

This soil has developed from shaly limestone under conditions of poor drainage. The quantity of organic matter is the result of the dense growth of wild slough and prairie grasses which flourished on the soil. In some areas where the organic matter has not been completely incorporated with the soil, there is a layer of muck on the surface.

Occurrence.—The acreage of poorly drained Sogn silt loam aggregates about 2 square miles in Olmsted County, occurring in small scattered areas in association with rough stony slopes and shallow-phase soils. It usually occurs on narrow benches where bedrock crops out and where it receives seepage and slope drainage from higher areas. The soil in these positions varies greatly in the depth to which incorporation of organic matter has taken place. In many places it is deeper than typical and the subsoil is dark-drab mottled clay. In some places scattered drift materials are present and the soil resembles the Clyde soils.

The surface soil is modified and varied to some extent by coarser materials which have been washed down from higher lands. Coarser-textured loamy topsoils occur on areas in sections 24 and 28 of Marion Township. In some other localities, the topsoil is silty clay. This soil also occurs on slopes where the shaly limestone has been exposed to weathering. Usually these slopes are at the line of outcrop of less elevated bedrock. The bedrock at high or average elevations are frequently siliceous or coarser-grained limestone and sandstone, as in areas in section 20 of New Haven Township.

General condition.—This land varies from level on bench positions to steep on slopes. Underdrainage is very poor, but surface

run-off varies from moderate to excessive. Seepage waters from the slopes and above the bedrock drain on to the soil on the benches and keep it almost permanently saturated or poorly drained. In many places the grass sod is hummocky in appearance and is swampy. On steep lower slopes seepage keeps the surface soil well supplied with moisture.

Practically none of this soil is cultivated. The lower-slope positions are forested or support a good growth of prairie pasture grass. The poorly drained benches are kept in pasture on which the grass growth is rank and withstands the driest seasons. This soil occurs in such small bodies that no methods of improvement are suggested for it alone. Pasturage is excellent, and occasional wild hay is made.

WABASH SILT LOAM

Description.—The topsoil of Wabash silt loam is very dark grayish-brown or black mellow silt loam, rich in organic matter, and about 20 inches deep. The subsoil is dark-brown silty clay loam material moderately compact and rather plastic when wet. Below a depth of 30 inches the texture of the lower part of the subsoil is silty clay loam and the material is mottled with light and dark gray and is stained by rust-brown iron concretions.

Occurrence.—Wabash silt loam covers 19.7 square miles in Olmsted County, which is about three-fifths of the bottom lands of the county. This soil occurs on flood plains of streams and drainage ways where deposition has taken place under conditions of sluggish overflow waters. The largest area is in the valley of North Branch Root River, in Orion Township. The valley is dissected to a depth of 150 feet or more below the uplands, but is broad (one-half mile wide in places), bordered by terraces and low uplands. The rate of descent of North Branch Root River is greater than usual for the streams of this region. Overflow periods are infrequent and usually of short duration.

Another large area of Wabash silt loam is on the flood plain of Willow Creek. Here the valley is dissected about 100 feet below the uplands and ranges in width from one-fourth to one-half mile. Because dissection in this valley is not very deep and the rate of flow is rather sluggish, the bottom is frequently inundated for short periods. The soil is rather poorly drained on more depressed areas, the topsoil is heavier in texture, and the subsoil is more plastic than typical. In places the topsoil is silty clay loam with a thin surface layer of muck.

Similar to Willow Creek bottoms are the silt loam bottoms of Cascade Creek. Along other major streams of the county, Wabash silt loam generally occurs in a position above areas of loam and sandy loam bottom lands. Toward the drainage heads the bottoms become more and more narrow until the colluvial slopes, on which occur Buckner silt loam, extend to the streams. Where Wabash silt loam adjoins areas of Buckner silt loam, its subsoil is lighter in texture than typical, resembling the Buckner soil. In many places surrounding the headwaters of streams and on small tributary or upland drainage ways, Wabash silt loam merges into Clyde and Bremer soils. On bottoms of loam and sandy loam, Wabash silt loam fre-

quently occurs in backwater depressions, such as those in section 11 of New Haven Township.

In a few areas, where the soil occurs in a backwater overflow position now reached by only the highest flood waters, the subsoil contains more lime, as in section 7 of Rochester Township. The topsoil here is heavy silt loam or silty clay loam. Where it occurs along or in upland drainage ways within areas of lighter-colored soils, the topsoil is sometimes lighter in color than typical.

General condition.—Underdrainage is somewhat sluggish and where periodic overflow waters are not carried off by the channel, drainage conditions make cropping uncertain. The more depressed areas remain saturated for some time after each overflow. Wild prairie and slough grasses abound and are utilized for hay and pasturage. On better-drained areas a more desirable bluegrass pasturage is maintained.

Crops.—When the soil is sufficiently protected from overflow, cropping to corn and tame hay is practiced, and excellent yields are produced. Small grains are not so well adapted to this soil, their yield being reduced on account of rank growth and late-maturing grain which results in damage from lodging and rusting. Corn yields average from 45 to 50 bushels an acre; oats and barley, from 25 to 30 bushels each; and wheat and rye, from 15 to 20 bushels each. Clover and timothy hay produces from 2 to 2½ tons an acre; clover alone, about 2¼ tons; timothy alone, 1½ to 2 tons; and wild hay grasses, 1½ tons. Some of the larger tracts are used for grazing livestock.

Because its topsoil is mellow and contains so much organic matter, Wabash silt loam may be plowed under a moderate range of moisture conditions, and good tilth maintained. Where it is cropped, the growing of grains is carried on more continuously than on most soils. Where drainage conditions have been corrected, this is recognized as a very fertile soil.

There has been but little artificial drainage on Wabash silt loam, and it is doubtful if such improvement is warranted because of the comparatively small size of the areas. This soil can best be utilized as pasture land.

Land values.—Land values of Wabash silt loam depend upon drainage conditions, overflow frequency, nearness to markets, character of associated lands, and farm improvements. Cultivable land has a value as high as that of the Tama soils; but pasture land of poorer drainage would probably average not more than $50 an acre in selling price.

WABASH LOAM

Description.—To a depth of about 20 inches Wabash loam consists of dark-brown or almost black loam. This is underlain by dark-brown silty clay loam, which at a depth of about 36 inches is faintly mottled. The topsoil is very friable, but when wet it is moderately coherent. The subsoil is friable, and sometimes rather plastic when wet, especially in the lower portion.

This soil has been deposited by streams on flood plains, and the surface is still being built up by periodic overflows. The topsoil is rather porous, but the subsoil is moderately retentive of moisture.

In some places the topsoil varies from sandy loam to heavy loam, and the subsoil is very little heavier than the topsoil, and is less plastic and compact than typical.

Occurrence.—The total acreage of Wabash loam in Olmsted County is equal to 10.8 square miles. The largest areas occur on South Branch Zumbro and North Branch Root River bottoms, where the soil has developed from coarser sediments laid down by overflow waters. It generally occurs in drainage courses, intermediate in elevation between Wabash silt loam above and Cass sandy loam below. On North Branch Root River bottom in Pleasant Grove Township the soil occurs on a narrow gorgelike bottom above the wider flood plain of Wabash silt loam. Where Wabash loam has developed on small tributary bottoms, the loamy texture of the topsoil is usually caused by the sandier deposits from the uplands or terraces in the watershed of the drainage system.

On North Branch Whitewater River bottom in the northeastern part of Quincy Township the surface soil is gravelly and stony, and in some places the subsoil is pebbly sandy loam, much lighter in texture than typical. In section 1 of Rock Dell Township and in section 12 of Rochester Township the topsoil is heavy loam or silt loam, and the subsoil is sandy loam or loamy sand.

General condition.—The frequency of overflow on Wabash loam is variable. On broader bottoms, the higher parts, or those most distant from the channel, overflow least frequently; and on such areas cropping can be carried on with some certainty in normal seasons. Such an area lies just west of Salem Corners in Salem Township, and another one is mapped in section 9 of Rochester Township. On narrow bottoms of deeper dissection overflow occurs with more frequency, and crop returns are uncertain.

This soil is utilized almost entirely as pasture land. It maintains a good stand of bluegrass and of wild prarie or slough grasses, except during long periods of dry weather. Flood waters seldom remain on the land sufficiently long to harm the pasture grasses. Trees on this land are oak, ash, elm, and willow.

Crops.—Some areas of the soil not affected by ordinary flood waters are cropped. Tame hay, corn, and small grains are the principal crops grown. Small grains suffer less from lodging, and yields are generally better on Wabash loam than on Wabash silt loam bottoms; but corn and hay yields are usually not so high.

Land value.—This soil is valued for permanent pasture, and where farms include medium-sized areas in conjunction with good cultivable lands the farm value is not affected, but where this soil forms a large proportion of the farm the value is reduced. It is doubtful if it would be advisable to protect the soil artificially from overflow, as it occurs in very small areas.

CASS SANDY LOAM

Description.—Cass sandy loam consists of dark-brown sandy loam, to a depth of about 15 inches, underlain by brown or pale yellowish-brown loose, porous loamy sand. The soil ranges in texture from loam to fine sandy loam or loamy sand, subject to variation because of the deposits of periodic overflows. Typically, the subsoil is more

porous and lighter in texture than the topsoil, but in some areas the subsoil material has the same texture and structure as the topsoil. In some places thin layers of silty material occur in the soil, but not in sufficient quantity to improve its water-holding capacity to any great extent.

Occurrence.—Cass sandy loam covers 2.7 square miles in Olmsted County, occurring as first-bottom lands along the larger streams. It sometimes occurs in low places back from the stream on the outer edge of the bottom where it has been affected by sediments washed down from adjacent sandy terraces or uplands. Such areas occur in section 3 of New Haven Township and section 14 of Cascade Township. The entire bottom of Bear Creek in Marion Township comprises this soil, and here it borders sandy terrace and upland areas.

Cass sandy loam occurs on the bottoms of the main branches of South Branch Zumbro River, where it adjoins Wabash loam. However, it usually occurs on narrower bottoms more deeply dissected by swift currents than does Wabash loam. Patches too small to map were found along North Branch Root River and on Whitewater River bottoms, but were included in mapped areas of other bottomland soils.

General condition.—Because of its overflow position, this soil is kept mainly in pasture and little effort is made to cultivate it. Fairly good pasturage is afforded except during dry periods. Usually some trees grow on this land, principally oak, ash, elm, and willow. The land is best suited for pasture.

Land value.—No land values can be given, but this soil detracts from the value of the farms on which it is found.

ROUGH STONY LAND

Description.—All lands which are too steep to be cultivated, which have on their slopes outcrops of bedrock limestone and sandstone with only thin coverings of soil material, and which lack the characteristics of a definite soil type, are grouped together and classed as rough stony land. Where the soil layer on steep slopes is 2 or more feet deep and possesses the more definite characteristics of a given soil type, it is mapped as that soil, or as a shallow phase of it. Rough stony land usually adjoins areas of shallow phase soil.

Occurrence.—Rough stony land covers 16.4 square miles in Olmsted County. It is indicated on the map as narrow strips including escarpments which vary in steepness and height and which form dividing lines between terraces and bottoms, uplands and bottoms, upland and terraces, and other upland areas. Near Little Valley in Quincy Township areas occur between two levels of upland. The most prominent ledges are those which mark the rims of small circular buttes. These bedrock ledges range in height from 50 to 150 feet above the upland levels. Three of these buttes are mapped in section 29 of Farmington Township. These higher bodies are but slightly dissected by drainage ways and the outcrops on slopes serve as barricades to further development of the drainage of adjacent uplands.

The escarpments between uplands and bottoms are usually most precipitous. In some places picturesque dells are formed, such as

those along North Branch Whitewater River in Quincy Township. (Pl. 42, fig. 2.) The largest areas lie along North Branch Root River, in Pleasant Grove and Orion Townships, along North Branch Whitewater River in Quincy Township, and along South Branch Zumbro River in Cascade and Oronoco Townships.

General condition.—The larger areas of rough stony land are usually forested. The forest growth consists mostly of poplar, maple, ash, basswood, oak, elm, and wild plum, with an undergrowth of hawthorn, hazel bush, wild raspberries, and blackberries. On better protected slopes some pasturage is produced, and the tree growth supplies wood for use on the farms either as fuel or for building purposes. The rocky slopes, eroded of soil, are bare of vegetation, save for a sparse growth of grass which supplies scant pasturage. The ledges of rock have been quarried; the rock is used principally for cisterns, foundations for small farm buildings, and for walks.

MUCK

Description.—Muck consists of a mass of black, partly decomposed organic matter which contains mineral soil material that varies in texture from clay to coarse sand. Disintegration of the organic parent material has taken place to such an extent that the plant forms are lost and are incorporated within the soil. Muck is light in weight and is of a somewhat spongy nature. When wet it is slightly plastic, but when dry it has a tendency to bake and crack.

This surface material of muck varies in depth from 14 to 20 inches, and is underlain by very dark grayish, almost black, silty clay loam or silty clay, very plastic when wet and moderately friable when dry. Below 30 inches there is usually less organic matter and the soil is more compact, tough, and plastic, and is usually mottled in color. The texture of the subsoil is varied by the quantities of sand and gravel which it contains. In some places it is sandy clay loam.

In some areas the organic matter is not so completely disintegrated as it is in typical muck, the plant forms are still recognizable, the organic matter is not incorporated with mineral matter within a foot of the surface, the mineral matter is not consolidated within 3 feet of the surface, and the material is more compact to depths of 3 or more feet. Such deposits are called peat, but because of their small extent they were not mapped separately. There are three such areas, one in section 18 of High Forest Township, one in section 2 of Kalmar Township, and one in section 8 of Salem Township. The area in High Forest Township occurs on a seepage slope, and the other two on former lake beds below uplands which are now traversed by sluggish drainage ways.

Occurrence.—Muck covers 4½ square miles in Olmsted County. The largest areas occur in High Forest and Rock Dell Townships. It usually adjoins areas of glacial drift or drift that has been covered with a thin mantle of loess. Muck occurs in areas formerly occupied by lakes or swamps, where conditions have been favorable to the decomposition of rank vegetation and the accretion of organic remains as the waters receded. At the present time drainage is very poor. These conditions exist in backwater depressions on first bottoms, on the back part of terraces, in swampy places in upland

drainage ways, and in places on benches or slopes made wet by seepage.

General condition.—Drainage is extremely sluggish, and this condition renders the land unfit for cultivation. It is practically all in wild-grass meadows, which supply wild hay and pasturage. Where drainage improvements have beeen made muck has been utilized for truck crops such as potatoes, celery, and onions, rather than for field crops. An early maturing crop is preferable because of the likelihood of damage by early frosts in the depressed areas where muck occurs.

In its present state muck is best suited to hay and pasturage. It is doubtful whether any of the muck areas are of sufficient size to justify their improvement for cropping. No accurate appraisement of muck can be made because it occurs in such small areas. It reduces the value of farms on which it is present.

SUMMARY

Olmsted County is in the southeastern part of Minnesota, and has an area of 666 square miles.

The land is undulating or rolling, with an elevation of about 1,200 feet above sea level. It is well dissected by deeply cut drainage ways, from 50 to 250 feet below upland levels. Precipitous rock bluffs, the most conspicuous topographic features of the county, occur along many of the valley slopes. The county is well drained by South Branch Zumbro River, three branches of Whitewater River, and North Branch Root River.

Olmsted County was organized in 1858. The population is almost wholly native-born American.

Rochester, the county seat, is the largest town; and Stewartville, Eyota, Chatfield, Byron, and Dover are smaller towns mentioned in order of size. Two railroad systems supply ample transportation facilities for the county.

The average frost-free season is 142 days. The mean annual precipitation at Rochester is 27.89 inches, and it is normally well distributed throughout the growing season. The mean annual temperature is 43.2° F.

The average size of the farms in Olmsted County is 164.5 acres, and the equipment in buildings and implements is sufficient for the diversified farming which is practiced. In acreage, the cereal crops rank as follows: Corn, oats, barley, flax, rye, wheat, and buckwheat; and the hay grasses, timothy and clover mixed, timothy, clover, wild hay, and alfalfa. The livestock, according to numbers, rank as follows: Hogs, dairy cattle, beef cattle, horses, and sheep. The acreages of corn, small grains, and hay crops are nearly equal. Systematic rotation of crops is not commonly practiced. Practically the only fertilizer used is the manure produced on the farms.

Owners operate 69.2 per cent of the farms. Except during the harvest season there is sufficient high-class labor to supply the demand.

The value of the farms during 1923 ranged from $50 to $250 an acre, the average being about $125 an acre. This is considered below the normal market value.

The soils of Olmsted County may be classed in two groups according to the color of the topsoil. These are the dark-colored soils of the prairies and the light-colored soils in areas which have been or are now forested. With the exception of slightly weathered shallow soils, recently developed over limestone, the soils of this county have developed in a moderately humid region, and are leached of lime to a depth of several feet.

Included in the group of dark-colored soils are Tama, Carrington, Thurston, Dodgeville, Buckner, Waukesha, O'Neill, Clyde, Bremer, Muscatine, Sogn, Wabash, and Cass soils.

Tama silt loam has developed from loess on gently rolling uplands. It is unsurpassed for farming and is ideal for growing corn.

The Carrington soils have developed over glacial drift on uplands. They are used for general farming, and in the better areas are as valuable as Tama silt loam.

The Thurston soils have developed over sandy drift. They vary in value according to the quantity of sand and the porosity of the subsoil.

Dodgeville loam and Dodgeville silt loam are shallow soils underlain by limestone. Where these soils are 2 or more feet deep, they equal the Carrington soils in value, but the average value is not high.

Buckner silt loam occurs principally on colluvial slopes, and has a high agricultural value.

Waukesha loam and Waukesha silt loam occur on well-drained terraces. They are very productive and compare very favorably in this respect with the Carrington soils.

O'Neill loam and O'Neill sandy loam occur on terraces and are underlain by gravel. In very favorable seasons they produce well, but crop yields are not so good in dry seasons.

Muscatine silt loam has developed over loessial material on flat uplands. It is highly productive, and its agricultural value is generally equal to that of Tama silt loam.

Clyde silt loam and Clyde silty clay loam have developed from glacial drift on flat or in depressed areas. Where drainage has been improved they are very productive.

Bremer silt loam and Bremer silty clay loam occur on terraces. They are productive, but in some places drainage is deficient.

Wabash loam and Wabash silt loam comprise first-bottom lands which are subject to overflow. On this land crop yields are good in favorable years.

The Sogn soils are residual soils developed over limestone. A poorly drained phase of this soil having low agricultural value is mapped.

Cass sandy loam is poorly drained first-bottom soil and is underlain by sand and gravel. Its agricultural value is rather low.

The light-colored soils of Olmsted County lie along stream valleys where there is now or has been forest growth. The topsoils are brown or grayish brown, and the subsoils are brown or yellowish brown and are slightly heavier in texture than the topsoils. They are underlain, at a depth of 2 or 3 feet, by the parent material. In this group are the Clinton, Lindley, Boone, and Sparta soils.

Clinton silt loam has developed over loess. Where the surface is smooth this soil is productive, but the average yield is not so high

as that on Tama soils. Lindley silt loam and Lindley loam have developed over glacial drift. The rough surface of these soils detracts from their agricultural value.

Boone fine sand and Boone fine sandy loam have developed over sandstone. The soils are light in texture and shallow, in many places scarcely covering the bedrock. Their agricultural value is low.

Sparta loamy sand and Sparta sandy loam have developed on terraces from glacial-outwash materials. These soils are productive, but in some places drainage is excessive.

Muck and rough stony land total 20.9 square miles in the county.

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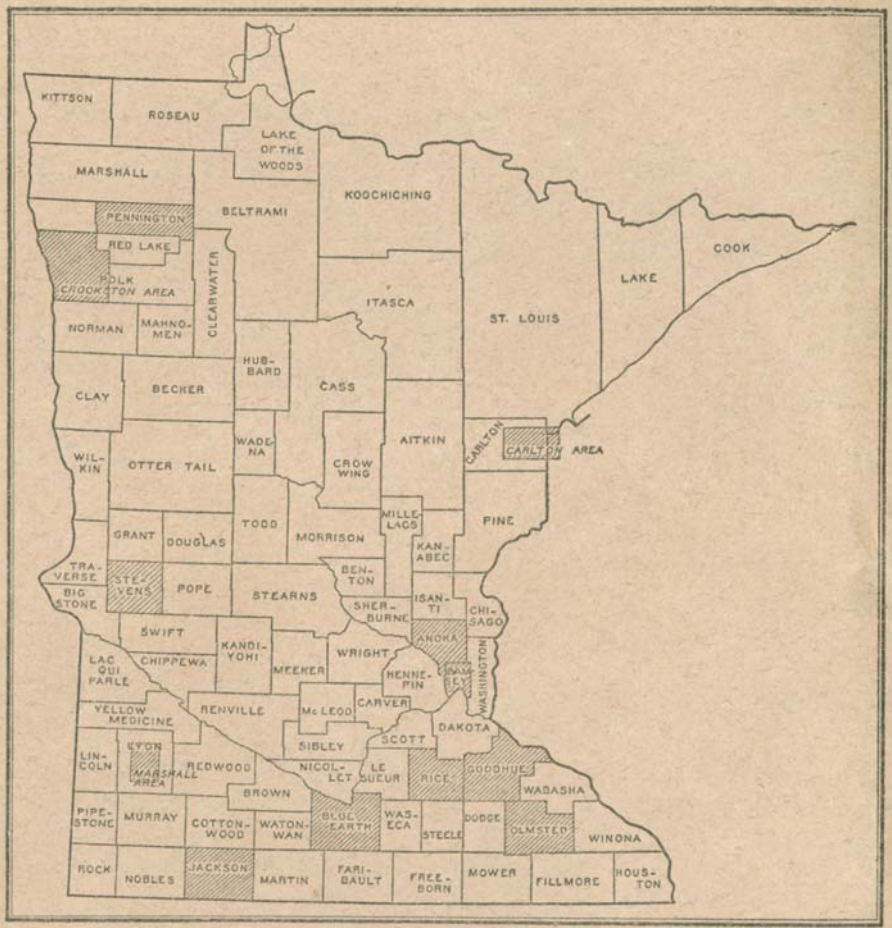

Areas surveyed in Minnesota, shown by shading

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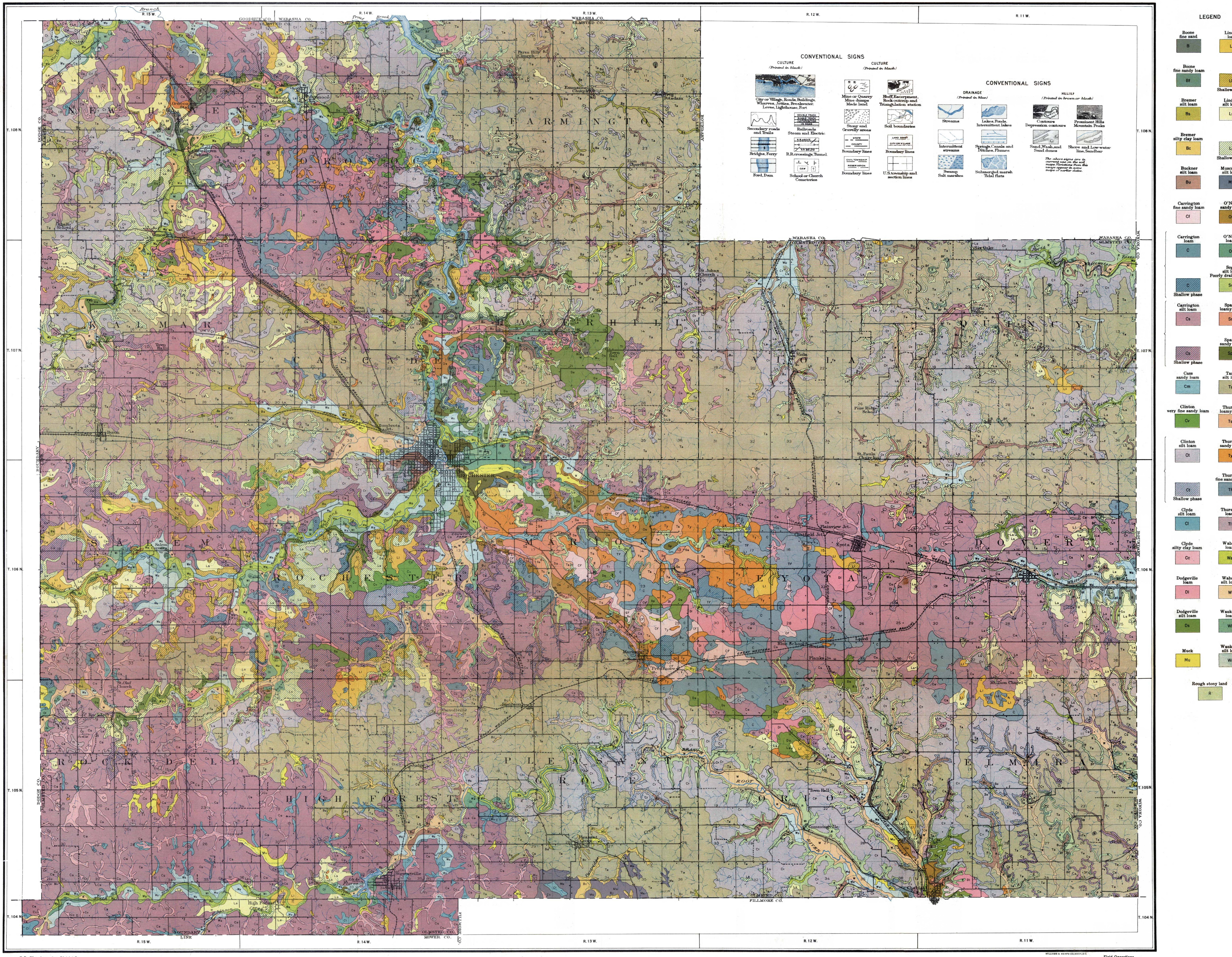
U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
A. G. MC CALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP

MINNESOTA
OLMSTED COUNTY


NEW HAVEN
ORONOCO
FARMINGTON
KALMAR
CASCADE
HAVERHILL
VIOLA
QUINCY
SALEM
ROCHESTER
MARION
EYOTA
DOVER
ROCK DELL
HIGH FOREST
PLEASANT GROVE
ORION
ELMIRA
GOODHUE CO.
WABASHA CO.
OLMSTED CO.
FILLMORE CO.
MOWER CO.
DODGE CO.
WINONA CO.
R. 15 W.
R. 14 W.
R. 13 W.
R. 12 W.
R. 11 W.
T. 108 N.
T. 107 N.
T. 106 N.
T. 105 N.
T. 104 N.
CONVENTIONAL SIGNS
LEGEND
Boone fine sand B
Boone fine sandy loam Bf
Bremer silt loam Bs
Bremer silty clay loam Bc
Buckner silt loam Bu
Carrington fine sandy loam Cf
Carrington loam C
C Shallow phase
Carrington silt loam Cs
Cs Shallow phase
Cass sandy loam Cm
Clinton very fine sandy loam Cv
Clinton silt loam Ct
Ct Shallow phase
Clyde silt loam Cl
Clyde silty clay loam Cc
Dodgeville loam Dl
Dodgeville silt loam Ds
Muck Mu
Lindley loam Ll
Ll Shallow phase
Lindley silt loam Ls
Ls Shallow phase
Muscatine silt loam Ms
O'Neill sandy loam Os
O'Neill loam Ol
Sogn silt loam, Poorly drained phase So
Sparta loamy sand Ss
Sparta sandy loam Sp
Tama silt loam Ta
Thurston loamy sand Ts
Thurston sandy loam Ty
Thurston fine sandy loam Tf
Thurston loam Tl
Wabash loam Wa
Wabash silt loam W
Waukesha loam Wl
Waukesha silt loam Ws
Rough stony land R

T.D. Rice, Inspector, District 3
Soils surveyed by J. Ambrose Elwell, in charge, G. B. Shivery,
B. H. Hendrickson, Mark Baldwin, and A. T. Sweet

Scale 1 inch - 1 mile

Field Operations
Bureau of Soils
1923